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DELAWARE RIVER BASIN  
UNNAMED TRIBUTARY OF TROUT CREEK  
PENNSYLVANIA

NDI ID PA 00743

PA DER 45-246

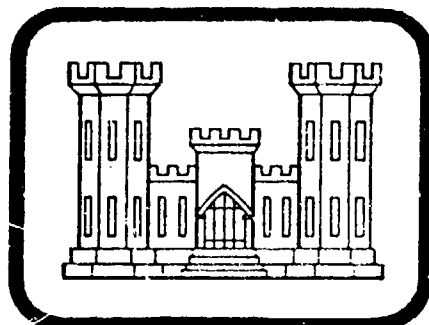
LEVEL *11*

## NORTH ARROWHEAD LAKE DAM

OWNED BY

ALL-AMERICAN REALTY CO., INC.

PHASE I INSPECTION REPORT  
NATIONAL DAM INSPECTION PROGRAM



*DA CW 31-81-C-0016*

PREPARED FOR

DEPARTMENT OF THE ARMY  
BALTIMORE DISTRICT CORPS OF ENGINEERS

BALTIMORE, MARYLAND  
21203

BY



**O'BRIEN & GERE**

PHILADELPHIA, PENNSYLVANIA  
19103

AUGUST 1981

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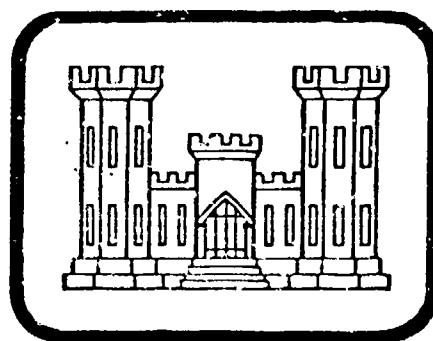
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Prepared for:

DEPARTMENT OF THE ARMY  
Baltimore District, Corps of Engineers  
Baltimore, Maryland 21203

Prepared by:

O'BRIEN & GERE ENGINEERS, INC.  
1617 J F Kennedy Boulevard - Suite 1760  
Philadelphia, Pennsylvania 19103

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## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I REPORT  
NATIONAL DAM INSPECTION PROGRAM

Name of Dam:	North Arrowhead Lake Dam
State:	Pennsylvania
County:	Monroe
Stream:	Unnamed tributary of Trout Creek
Coordinates:	N 41° 09.6' W 75° 34.4'
Date of Inspection:	April 8, 1981

ASSESSMENT

North Arrowhead Lake Dam is an 11-year old earth embankment which impounds a lake used for recreational purposes. The dam is constructed in two sections: a 1,400-foot long, 21-foot high earth embankment dam with a 60-foot wide concrete Ogee spillway at its eastern abutment, and a 970-foot long, 14-foot high earth embankment levee, located approximately 1,000 feet to the east of the dam. The crest widths average 15 feet and 20 feet for the dam and levee, respectively. With the water surface at spillway crest elevation, North Arrowhead Lake has a surface area of approximately 87 acres. The maximum storage capacity of the impoundment is 942 acre-feet at the low point of the top of the dam. The dam has a concrete intake structure, equipped with stoplogs to control the water level in the impoundment, a 20-inch diameter drain extending under the dam and a gate valve at the discharge end of the drain pipe. An ungated 10-inch diameter standpipe and drain is located at the levee.

North Arrowhead Lake Dam is a "Small" size, "Significant" hazard Dam. The recommended Spillway Design Flood (SDF) for a "Small" size, "Significant" hazard dam ranges from the 100-year flood to one-half of the Probable Maximum Flood (PMF). Because of the extent of the potential hazard area, the selected SDF is one-half of the PMF. The spillway is capable of discharging the SDF without overtopping the low point of the dam. Therefore, the spillway is classified as "Adequate".

Based upon visual inspection of the dam and review of the drawings provided by the Pennsylvania Department of Environmental Resources (DER), North Arrowhead Lake Dam is considered to be in poor condition. The observed deficiencies are reflected in the following recommendations and remedial measures and discussed in detail in the appropriate sections of this report.

Recommendations and Remedial Measures:

The recommendations and remedial measures should be initiated immediately.

a. Facilities.

The Owner should retain the services of a licensed professional engineer, experienced in the design and construction of dams, to assist in the implementation of the following recommendations:

NORTH ARROWHEAD LAKE DAM  
NDI ID PA-00743

1. Erosion protection should be installed on the upstream face of the dam, where necessary, to prevent erosion due to wave action. In addition, erosion protection should be provided along the upstream face of the levee, at the outlet of the 20-inch diameter lake drain pipe and on the banks of the spillway discharge channel.

2. A means of upstream closure should be provided to facilitate drawdown of the reservoir and to prevent the drain pipe from being subjected to constant hydrostatic pressure. Also, access should be provided to the intake structure located in the reservoir.

3. The steep slopes in the vicinity of lake drain outlet pipe and along the spillway discharge channel should be cut back and reseeded to prevent sloughing and erosion.

4. The toe drain system should be removed and replaced at the designed elevation to enable it to function properly.

5. Deteriorated concrete should be repaired on the outlet headwall for the lake drain pipe.

6. Spalled concrete surfaces should be repaired on the Ogee spillway section at its base and its junction with the concrete discharge apron.

7. Irregular surfaces on the dam and levee should be regraded and backfilled with suitable compacted material, where necessary.

The Owner should initiate the following remedial measures:

1. Small trees and brush on both the dam and the levee, and along the banks of the outlet channels, should be removed. All resulting voids should be backfilled with suitable compacted material.

2. The sloughed area on the downstream slope of the levee should be repaired and monitored.

3. Animal burrows on the crest of the dam should be backfilled with suitable compacted material.

4. A grass cover should be established and maintained on all embankment surfaces of the dam and levee.

5. Seepage observed at the downstream toe of the dam should be monitored.

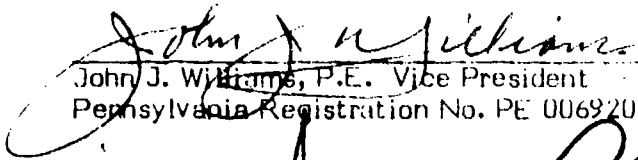
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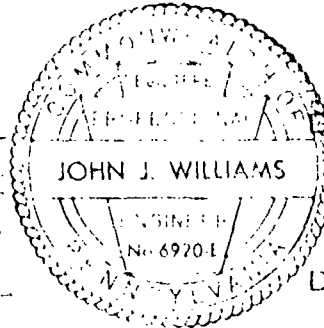
b. Operation and Maintenance Procedures

1. An operation and maintenance program should be developed and implemented. This program should include periodic operation of outlet works, routine maintenance tasks, and an annual inspection performed by a licensed professional engineer, experienced in the design and construction of dams.

2. A monitoring and downstream warning plan should be developed and implemented during periods of extreme rainfall so that downstream residents and the appropriate agencies are notified in case of an impending dam failure.

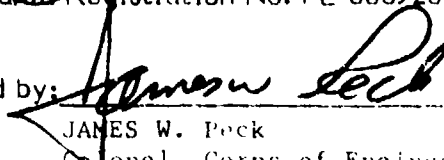
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John J. Williams, P.E. Vice President  
Pennsylvania Registration No. PE 006920E

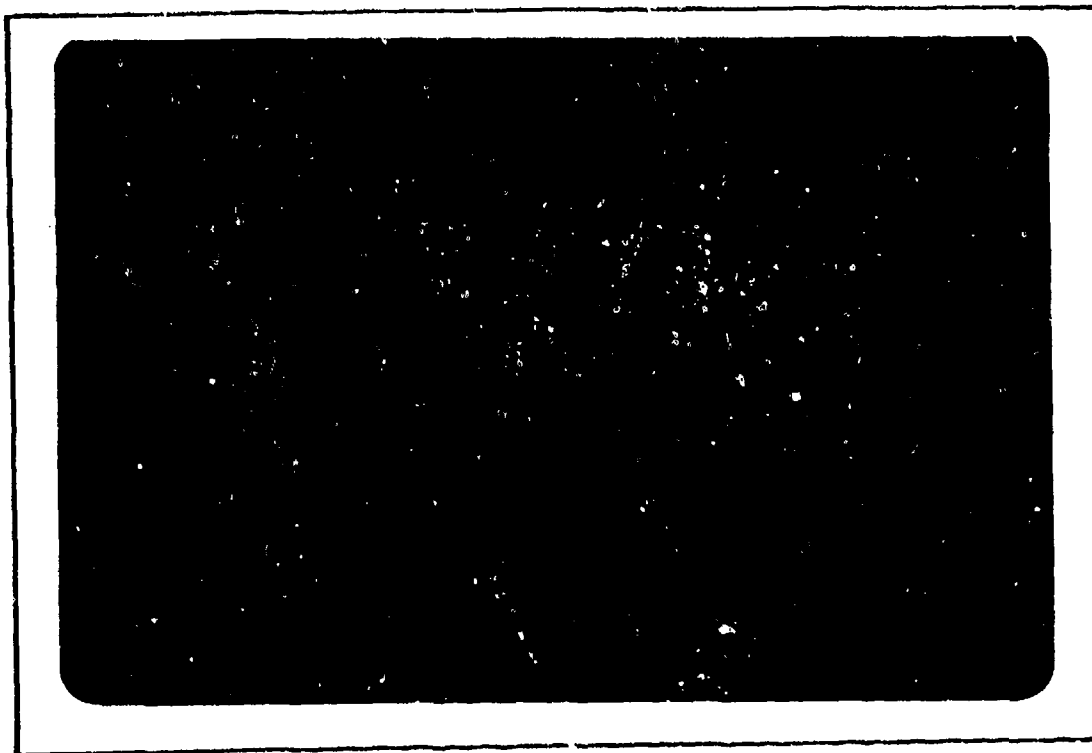


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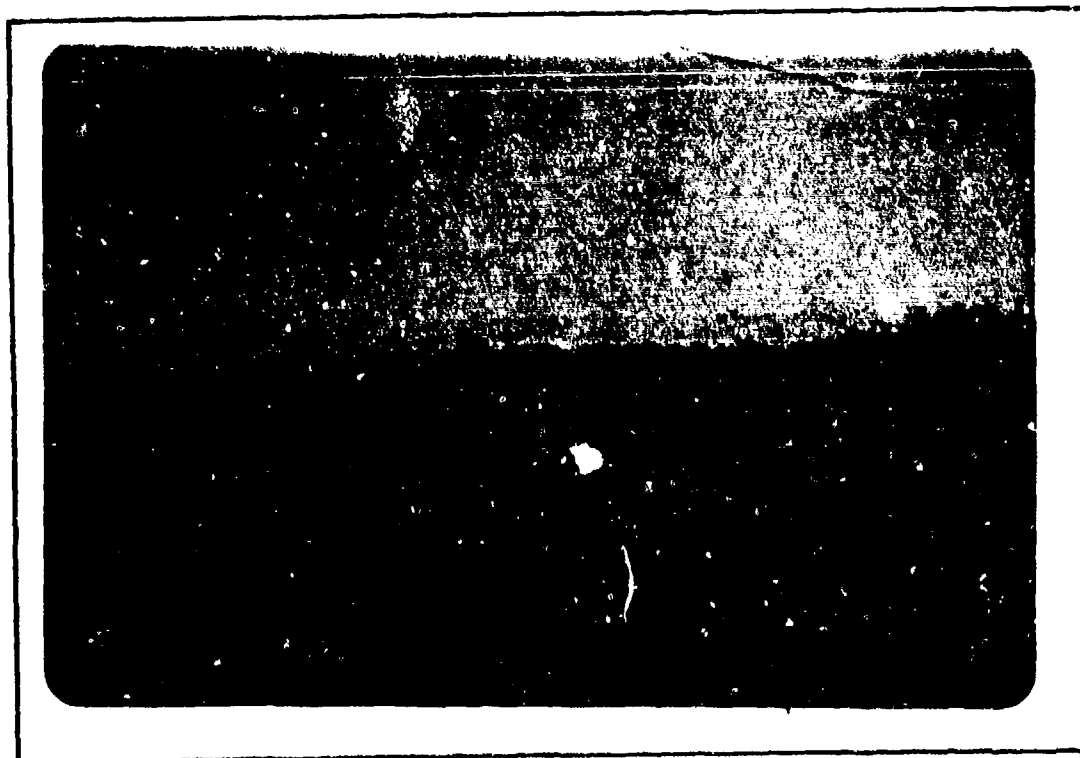
Approved by:

  
JAMES W. Peck  
Colonel, Corps of Engineers  
District Engineer

Date: 31 Aug 81



UPSTREAM OVERVIEW FROM THE LEFT ABUTMENT. (4/8/81)



DOWNSTREAM OVERVIEW FROM THE RIGHT SIDE. (4/8/81)

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## PHASE I REPORT

### NATIONAL DAM INSPECTION PROGRAM NORTH ARROWHEAD LAKE DAM NDI ID PA-00743 PA DER 45-246

#### SECTION 1

#### PROJECT INFORMATION

##### 1.1 General

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine to what extent the North Arrowhead Lake Dam constitutes a hazard to human life and property.

1.2 Description of Project (Based upon information obtained from the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, PA., from Mr. Leonard Tusar of Monroe Engineering and from the inspection).

a. Dam and Appurtenances. North Arrowhead Lake Dam is an 11-year old earth embankment, constructed in two sections: one consisting of a 1,400-foot long, 21-foot high earth embankment with a concrete Ogee spillway, and the other consisting of a 970-foot long, 14-foot high levee, located approximately 1,000 feet to the east of the main dam. These embankments impound North Arrowhead Lake with a surface area of 87 acres at the spillway crest elevation. The maximum storage capacity of the impoundment is approximately 942 acre-feet at the low point of the top of the dam elevation. The main dam has an average crest width of 15 feet and an approximate downstream slope of 5H:1V. The upstream slope varies between 3 and 5H:1V and is intermittently covered with random size riprap. The levee has a top width of approximately 20 feet, side slopes averaging 4H:1V and no riprap protection along its upstream face. The main dam is believed to have been constructed with an impervious central core. No information with respect to the construction of the levee is available.

A 60-foot long concrete Ogee spillway is located at the eastern abutment of the main dam. It consists of a 25-foot long concrete approach apron, a concrete Ogee section, and a 25-foot long concrete discharge apron, which is approximately six feet lower than the crest of the Ogee. The spillway has concrete side walls which are approximately six feet higher than the Ogee crest and extend approximately 25 feet upstream and downstream of the overflow weir. As indicated on Sheet 6 of Appendix E, cutoff walls of unspecified dimensions have been provided under both sides of the Ogee section, and a 2.5-foot deep keywall is provided at the

downstream end of the discharge apron. The outlet channel tapers from a base width of 60 feet at the spillway outlet to a base width of 15 feet approximately 80 feet downstream of the spillway. The sides of the outlet channel just downstream of the spillway are approximately 8 feet high, but they get progressively lower as the channel extends downstream. The side slopes are generally 2H:1V and they have no protection against erosion.

A 4-foot square concrete drop gate chamber is located near the center of the dam, approximately 40 feet into the lake from the dam crest. The structure has horizontal stoplogs to control the water level in the lake and a bar screen to prevent floating debris from clogging the outlet pipe. Located at the bottom of the chamber is a 20-inch diameter corrugated steel pipe, encased in concrete, which extends under the dam to an outlet channel. According to plans of the dam, cutoff collars have been provided at 25-foot intervals along the pipe. Located at the end of the outlet pipe is a small concrete headwall and a free-standing 20-inch diameter gate valve.

The outlet works for the levee portion of the dam consist of a 10-inch diameter standpipe, which extends approximately a foot above normal pool elevation, and approximately 350 feet of 10-inch diameter pipe which discharges into a swamp area near Arrowhead Lake. No construction information for this pipe is available.

Four-inch diameter toe drains extend from each side abutment to the outlet channel near the center of the dam. These drains are very shallow and are surrounded by coarse crushed stones. No toe drain system exists at the levee.

b. Location. North Arrowhead Lake Dam is located on an unnamed tributary of Trout Creek in the Coolbaugh Township, Monroe County, Pennsylvania. To illustrate the location, a portion of the USGS Quadrangle entitled "Thornhurst, PA." has been included as Figure 1 of Appendix E. USGS reference coordinates for this dam are N41°09.6' and W75°34.4'.

c. Size Classification. North Arrowhead Lake Dam has a maximum storage capacity of 942 acre-feet and a maximum height of 20 feet. The dam is therefore classified as a "Small" size dam (height less than 40 feet and storage less than 1,000 acre feet).

d. Hazard Classification. A small fire station, located approximately 350 feet downstream of the dam, and 10 houses located along the shores of Arrowhead Lake (El. 1656') constitute the hazard area downstream of North Arrowhead Lake Dam. A failure of the dam could cause appreciable property damage, with the possible loss of a few lives. Therefore, North Arrowhead Lake Dam is classified as a "Significant" hazard structure.

e. Ownership. The dam is owned by the All-American Realty Co., Inc.; 45 Essex Street; Hackensack, New Jersey; 07601. (Telephone Number: 201-488-6565). Monroe Engineering, Inc., East Stroudsburg, Pa, 18301 represents the Owner. All correspondence should be directed to Leonard Tusar of Monroe Engineering, Inc.

f. Purpose of the Dam. The dam was constructed to provide a lake for recreational use. The lake is currently being used for this purpose.

g. Design and Construction History. North Arrowhead Lake Dam was designed by Monroe Engineering, Inc., of East Stroudsburg, Pennsylvania, and constructed in 1970 by George H. Litts, Inc., of Marshalls Creek, Pennsylvania. The dam was constructed without first obtaining a permit from the Pennsylvania Department of Environmental Resources (DER). Consequently, the Owner was required to have several borings and a few test pits dug in order to verify that satisfactory construction was achieved. Geo-Surveys of Camp-Hill, Pennsylvania, performed the necessary subsurface investigations. Since the dam was originally constructed, riprap has been added along the upstream face of the dam (1972).

h. Normal Operating Procedures. The reservoir surface is normally maintained at the spillway crest Elevation 1668. Drawdown of the lake may be accomplished by removing stoplogs and by opening the gate valve at the outlet of the 20-inch diameter drain pipe.

### 1.3 Pertinent Data

a. Drainage Area.

Square Miles	1.0
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b. Discharge at Dam Site (cfs).

Spillway (water surface at top of dam low point, El. 1672.8)	2,210
Spillway (water surface at top of dam design elevation, El. 1674)	3,086
Outlet Works (water surface at normal pool, El. 1668)	33

c. Elevation (MSL).

Top of Dam (Design)	1,674.0
Top of Dam (Low Point)	1,672.8
Spillway Crest	1,668.0
Outlet Works (Inlet Invert)	1,654.0
Outlet Works (Outlet Invert)	1,653.0
Streambed at Toe of Dam	1,653.0

d. Reservoir Length (feet).

Normal Pool, Elev. 1,668.0	3,200
Maximum Non-overtopping Pool, El. 1672.8	3,400

e. Storage (Acre-Feet).

Normal Pool, El. 1668	433
Top of Dam (Low Point), El. 1672.8	942
Top of Dam (Design), El. 1674	1,075

f. Reservoir Surface Area (Acres).

Normal Pool, El. 1668	87
Top of Dam (Low Point), El. 1672.8	127
Top of Dam (Design), El. 1674	133

g. Dam Data.

1. Main Dam

Type	Earth Embankment
Length	1,400 Feet
Height to Low Point of Dam	20 Feet
Crest Width	15 Feet
Side Slopes (Upstream)	3 to 5H:1V
(Downstream)	Averages 5H:1V
Zoning	Random Material - Finest Material Nearest Impervious Core
Impervious Core	Impervious earth core shown on drawings
Cutoff	Cutoff Trench
Grout Curtain	None

2. Levee

Type	Earth Embankment
Length	970 Feet
Height to Low Point of Dam	13 Feet
Crest Width	20 Feet
Side Slopes	Average 4H:1V Upstream and Downstream
Zoning	Unknown
Impervious Core	Unknown
Cutoff	Unknown
Grout Curtain	Unknown

h. Spillway. (Main Dam)

Type	Concrete Ogee Overflow
Length of Weir	60 Feet
Crest Elevation	1668.0 Feet
Gates	None at Spillway
Upstream Channel	25-foot long concrete approach apron
Downstream Channel	25-foot long concrete discharge apron to earth channel with 15-foot base width, 2H:1V side slopes and sides of varying height. Channel length is approximately 650 feet to twin 36-inch diameter CMP's under Lake Shore Drive. Slope averages 0.8 percent.

## SECTION 2

### ENGINEERING DATA

#### 2.1 Design

a. Data Available. The following information was provided by the Pennsylvania DER in Harrisburg, Pennsylvania:

1. Design Drawings for North Arrowhead Lake Dam:

- a. Location Plan
- b. General Plan
- c. Embankment Sections - Longitudinal
- d. Embankment Cross - Sections
- e. Spillway Plan & Details
- f. Embankment Drop Gate, Sections & Details

2. Miscellaneous correspondence, memoranda, etc.

b. Design Features. The design features are described in Section 1.2a and shown on the design drawings included in Appendix E. It should be cautioned, however, that the actual construction does not correlate very well with the design drawings. (See Section 2.2 below).

#### 2.2 Construction

The North Arrowhead Lake Dam and Levee appear to have been constructed to the general dimensions and with most of the features indicated on the Design Drawings. From visual inspection, however, the following discrepancies were noted:

a. The toe drain system illustrated on the drawings indicates that the drain pipe was to be installed a minimum of four feet deep. As illustrated on Photos 10 and 11 of Appendix C, the pipe is at or just below the ground surface.

b. Riprap was to have been installed along the upstream face of the dam (including two feet of the dam crest), along the first 120 feet of the low level outlet channel, and along the first 120 feet of the spillway outlet channel. At the time of inspection, riprap had been installed intermittently along the upstream face of the dam and no riprap was in evidence on the spillway outlet channel or the low level outlet channel. No riprap protection has been provided at the levee.

c. A 20-inch diameter gate valve is located at the outlet end of the low level outlet, as illustrated on Photos 7 of Appendix C. The design drawings indicate the low level outlet was to have free discharge with control provided at the intake structure.

d. The slope of the downstream faces of the dam and the levee were found to be approximately 5H:1V and 4H:1V, respectively. According to the drawings, a slope of 2 to 3H:1V was designed.

e. The length of the low level outlet indicated on the drawings appears to be much longer than that actually constructed. Consequently, the downstream slope of the embankment in the vicinity of the low level outlet headwall is approximately 1.5H:1V.

### 2.3 Operation

According to the Owner's representative, the outlet works have not been operated since the dam was constructed in 1970. Operation would consist of opening the 20-inch diameter gate valve and removing stoplogs from the intake structure. No means of draining the reservoir exists without first removing the stoplogs manually.

### 2.4 Evaluation

a. Availability. The engineering data presented in this report were provided by the Pennsylvania DER. Drawings may also be obtained from Monroe Engineering in East Stroudsburg, Pennsylvania.

b. Adequacy. The information provided by the Pennsylvania DER and Monroe Engineering, along with information obtained during the visual inspection, has been adequate for a Phase I evaluation of North Arrowhead Lake Dam.

c. Validity. As discussed in Section 2.2, several discrepancies exist between the design drawings and the actual construction.

## SECTION 3

### VISUAL INSPECTION

#### 3.1 Findings

a. General. North Arrowhead Lake Dam was inspected on April 8, 1981. At the time of inspection, the lake was at the spillway crest elevation of 1668. Underwater areas, other than those visible from the dam, were not inspected.

The observations and comments of the field inspection team are noted on a checklist included as Appendix A of this report.

b1. Dam. The dam appears to be in poor overall condition. No immediate structural problems were observed; however, the presence of several deficient conditions could lead to more serious problems if they are not corrected. The upstream face of the dam, for example, is intermittently covered with random size riprap. As a result, erosion has occurred and trees and brush are growing at those locations where protection has not been provided.

The crest of the dam and the area just above the riprap were also observed to be in poor condition. The dam crest is rutted and lacks sufficient grass cover, as illustrated on Photos 1 and 2 of Appendix C. In some locations, the crest elevation is as much as 1.2 feet lower than the design elevation 1674 (see profile sheet 11C of Appendix A). As illustrated on Photo 6 of Appendix C, small trees and brush are growing on the dam crest just above the riprap. This area was also found to be very irregular, which would likely hinder mowing or other similar maintenance procedures. Animal burrows were noted at a few locations near the western abutment.

The primary problems associated with the downstream slope of the dam include the growth of small trees and brush, an irregular ground surface and a very steep slope in the vicinity of the lake drain outlet pipe headwall. Minor brush growth and small trees were observed at scattered locations over the entire downstream slope. The uneven ground surface presents a maintenance problem, since mowing would be impossible over most of the downstream slope. The slope in the vicinity of the drain outlet headwall is particularly steep (approximately 1.5H:1V) and shows signs of sloughing into the outlet channel.

Seepage was noted in two locations. The first location was on either side slope of the outlet channel, approximately 40 feet downstream of the outlet headwall, where the toe drain pipes exit to the outlet channel. This seepage (1 to 2 gpm) appeared to be following the lining for the toe drain pipes, which were installed at or near the ground surface, as discussed in Section 2.2. The other seepage location was found just downstream of the east side toe drain pipe, as illustrated on Photo 10 of Appendix C. Water and very soft ground conditions were observed, but no evidence of piping could be found.

b2. Levee. The levee, located approximately 1,000 feet east of the dam, is of similar construction to that of the dam. It, however, has no protection on the upstream face and as a result, has been undermined by wave action (Photo 20, Appendix C). In addition, sloughing has occurred at several locations on the downstream slope of the levee (Photo 19, Appendix C). The grass cover is sparse, particularly on the upstream face and crest, where recreational vehicles pass over the levee. A few small trees and brush were noted near the western abutment.

The downstream slope of the levee is approximately 4H:1V and irregular at several locations. For the most part, the slope is in fair condition with no evidence of seepage. A wet area was noted just downstream of levee along Lake Shore Drive, but this appears to have been created by local runoff.

c. Appurtenant Structures. The spillway is located at the eastern abutment and consists of a six-foot high, 60-foot long, concrete Ogee section, with a crest elevation approximately two feet higher than the concrete approach apron. Except for minor spalling of the concrete Ogee section at its base and at its junction with the concrete discharge apron, the spillway appears to be in good condition (see Photo 3, Appendix C). It appears to have been constructed in compliance with the design drawings included in Appendix E.

The outlet works of the dam consist of a 4-foot square concrete intake structure, a 20-inch diameter drain pipe and a 20-inch diameter gate valve located at the discharge end of the drain pipe. Because the intake structure was not accessible, its construction and condition could not be determined. According to the Owner's representative, however, construction is in general conformance with the design drawings. The gate valve is believed to be operable, but has not been operated since it was installed in 1970. As illustrated on Photo 8, Appendix C, the concrete headwall has deteriorated and reinforcing steel is exposed.

The outlet works at the levee consist of a 10-inch diameter steel standpipe, which extends approximately one foot above the pool level (Photo 17, Appendix C), and approximately 350 linear feet of 10-inch diameter steel pipe which discharges to a swampy area just downstream of Lake Shore Drive. No construction data are available, but it does not appear that the outlet is gated.

d. Reservoir Area. The reservoir drainage area consists of approximately one square mile of relatively flat and forested land. Of the total area, approximately 50 percent is developed and 10 percent is a low-lying swampy area. The slopes adjacent to the impoundment are mild and covered with vegetation. No evidence of bank instability was observed.

e. Downstream Channel. The low level outlet discharges into a channel which conveys flow for a distance of approximately 650 feet to Arrowhead Lake. The channel has a very gentle slope, a varying base width and side slopes of roughly 4H:1V. (See Photo 9, Appendix C). Neither riprap protection nor an energy dissipator has been provided at the outlet of the 20-inch diameter drain.



The upstream portion of the spillway outlet channel is in poor condition. No riprap protection has been provided and the side slopes are very steep. Small trees are growing and sloughing has occurred along the sides of the channel. As the channel extends downstream, the banks diminish to approximately a foot in height at the point where it merges with the low level outlet channel.

### 3.2 Evaluation

The dam is considered to be in poor condition; however, the spillway is considered to be in good condition.

Several deficiencies were identified during the visual inspection: a) inadequate riprap protection along the upstream face of the dam and levee, at the outlet of the 20-inch diameter drain pipe, and along the spillway discharge channel; b) rutting and lack of cover on the crest of the dam and levee; c) growth of small trees and brush on both the dam and levee and along the banks of the outlet channels; d) lack of a proper low level intake and upstream control on the drain pipe; e) steep slopes in the vicinity of the outlet headwall and on the banks of the spillway channel; f) deterioration of the concrete headwall at the outlet of the lake drain and minor spalling at the base of the concrete spillway Ogee section; g) irregular surfaces on the dam and levee which hinders maintenance work; h) a toe drain system which was constructed at or near the ground surface; i) lack of access to the intake structure; and j) animal burrows on the crest of the dam.

## SECTION 4

### OPERATIONAL PROCEDURES

#### 4.1 Procedures

The only feature requiring operation at either the dam or the levee is the lake drain. In order to drain the lake, the operator must remove stoplogs at the intake structure and open the 20-inch diameter gate valve at the outlet of the drain pipe. This procedure is difficult to perform since access to the intake structure is not readily available.

#### 4.2 Maintenance of the Dam

No established maintenance program for the dam exists. According to the Owner's representative, maintenance is performed on an "as-needed" basis.

#### 4.3 Maintenance of Operating Facilities

According to the Owner's representative, the gate valve on the low level outlet pipe has not been operated since it was installed in 1970, and no maintenance has been performed at the intake structure.

#### 4.4 Description of Any Warning System In Effect

According to the Owner's representative, no formal surveillance and warning system is in effect at the North Arrowhead Lake Dam.

#### 4.5 Evaluation

The poor overall condition of the dam reflects the lack of an adequate operation and maintenance program. Once the recommendations discussed in Section 7 are implemented, a comprehensive operation and maintenance program should be instituted.

In addition, a formal surveillance and warning system should be developed and implemented during periods of extreme rainfall to warn downstream residents and the appropriate agencies of a possible dam failure or potential flooding.

## SECTION 5

### HYDROLOGY AND HYDRAULICS

#### 5.1 Evaluation of Features

a. Design Data. North Arrowhead Lake Dam has a contributing drainage area of approximately one square mile. The drainage area consists of moderately-sloped, forested, residential and swampy terrain ranging in elevation from 1880 at the northern boundary of the drainage area to 1668 at normal pool. From the upper reaches of the drainage area, runoff flows overland to an unnamed tributary of Trout Creek and then southerly along a slope of approximately 2.5 percent to North Arrowhead Lake. The southeasterly portion of the drainage area, comprising approximately 40 percent of the total area, is residential. No hydrologic or hydraulic calculations were available for review to assist in the preparation of this report.

b. Experience Data. No reservoir stage or other operation and maintenance records have been maintained. According to the Owner's representative, the spillway crest has never been overtopped by more than a few inches.

c. Visual Observations. The spillway appeared to be in good condition. Some erosion of the embankment was observed at the spillway abutments, but it appeared to have been caused by local runoff and pedestrian traffic rather than by overtopping. The spillway discharge channel was found to be in poor condition, as discussed in Section 3.

The outlet works consist of an intake structure with stoplogs, a 20-inch diameter outlet pipe, and a 20-inch diameter gate valve at the discharge end. Because the intake structure was not accessible, except by boat, the intake structure could not be inspected. The major problems associated with the outlet works appear to be the location of the gate valve and the lack of a proper low level intake. With the gate valve in its present location, the outlet pipe is under constant hydrostatic pressure, and the only way to lower the lake is to manually remove stoplogs.

d. Overtopping Potential. The recommended Spillway Design Flood (SDF) for a "Small" size, "Significant" hazard dam ranges from the 100-year flood to one-half of the Probable Maximum Flood (PMF). Because of the extent of the potential hazard area, the selected SDF is one-half of the PMF.

Hydraulic and hydrologic calculations were performed with the assistance of the HEC-1-DB computer program. Refer to Sheet 2, Appendix D for a brief description of the program. The peak design flood inflow to North Arrowhead Lake was computed to be approximately 960 cfs. The corresponding peak outflow was computed to be 655 cfs. The spillway capacity is 2,210 cfs, prior to overtopping the low point of the top of the dam, Elevation 1672.8.

e. Spillway Adequacy. The spillway at the North Arrowhead Lake Dam is capable of discharging the SDF without overtopping the dam; therefore, the spillway is classified as "Adequate".

## SECTION 6

### STRUCTURAL STABILITY

#### 6.1 Evaluation of Structural Stability

a. Visual Observations. Several deficiencies were observed which reflect existing or potential slope stability problems. Minor erosion and sloughing was observed along the upstream face of the dam, on the slopes adjacent to the headwall at the outlet of the 20-inch diameter drain pipe, and on the sides of the spillway discharge channel. It appears that wave action, coupled with the lack of adequate protection, has contributed to the erosion along the upstream dam face. At the other locations, it appears that the slopes are too steep and that sloughing will continue until stability is achieved.

Further evidence of potential problems include the presence of trees and brush on the dam and adjacent to the spillway outlet channel, lack of adequate riprap protection at the drain outlet, spalling of the concrete headwall at the dam low level outlet, the presence of animal burrows on the crest of the dam and seepage. At the time of the inspection, the dam appeared to be stable; however, continued deterioration could lead to structural problems.

b. Design and Construction Data. Design drawings and miscellaneous correspondence were provided by the Pennsylvania DER. No design calculations or construction data, however, were available from either the Pennsylvania DER or the Owner.

c. Operating Records. According to the Owner's representative, no operating records for this dam have been kept.

d. Post Construction Changes. The only construction known to have taken place since the dam was constructed in 1970 was the placement of riprap along the upstream face of the dam in 1972. No records or drawings of this post construction change are available.

e. Seismic Stability. North Arrowhead Lake Dam is located in Seismic Zone 1 according to the Seismic Zone Map of Contiguous States. A dam located in Seismic Zone 1 will generally be stable under expected Zone 1 earthquake conditions if it is stable under static loading conditions. Since the dam appeared to be stable for static conditions at the time of the inspection, it is expected that it would be stable for expected Zone 1 earthquake conditions.

## SECTION 7

### ASSESSMENT, RECOMMENDATIONS AND PROPOSED REMEDIAL MEASURES

#### 7.1 Dam Assessment

a. Evaluation. The visual inspection of North Arrowhead Lake Dam revealed that the dam is in poor overall condition. The reasons for this are failure to construct the dam according to the design drawings and lack of an operation and maintenance program. The following deficiencies are attributed to deviations from the design drawings: 1) inadequate riprap protection along the upstream faces of the dam and levee, at the outlet of the 20-inch diameter drain pipe and along the spillway discharge channel; 2) steep slopes in the vicinity of the low level outlet headwall and on the banks of the spillway outlet channel; 3) irregular surfaces on the dam and levee; 4) a toe drain system which was constructed at or near the ground surface rather than 4 feet below the ground surface; and 5) the presence of a 20-inch diameter gate valve at the outlet of the lake drain pipe. In addition, the following conditions were noted to be in conflict with recommended design practices: 1) lack of access to the intake structure; and 2) lack of a low level intake and upstream control gate on the lake drain pipe.

Lack of an operation and maintenance program has contributed to the following conditions: 1) rutting and lack of cover on the crests of the dam and the levee; 2) growth of small trees and brush on both the dam and levee and along the banks of the outlet channels; 3) deterioration of the concrete headwall at the outlet of the lake drain pipe and spalling at the base of the concrete spillway Ogee section; and 4) animal burrows on the crest of the dam.

Though these conditions do not appear to be critical at this time, it is important that they be corrected in a timely manner to ensure the future safety of the dam.

The selected SDF for North Arrowhead Lake dam is one half of the PMF. Based on a review of the hydrologic/hydraulic analyses, the spillway is capable of passing the SDF discharge before the low point of the crest of the embankment would be overtopped. The spillway is therefore "Adequate".

b. Adequacy of Information. The information provided by the Pennsylvania DER, along with the information obtained from the visual inspection and subsequent conversations with the Owner's representative, is considered adequate for a Phase I evaluation.

Urgency. The recommendations and remedial measures discussed in this section should be initiated immediately.

c. Necessity for Further Investigation. Further investigation at this time is not considered necessary.

## 7.2 Recommendations and Remedial Measures:

The recommendations and remedial measures should be initiated immediately.

### a. Facilities.

The Owner should retain the services of a licensed professional engineer, experienced in the design and construction of dams, to assist in the implementation of the following recommendations:

1. Erosion protection should be installed on the upstream face of the dam, where necessary, to prevent erosion due to wave action. In addition, erosion protection should be provided along the upstream face of the levee, at the outlet of the 20-inch diameter lake drain pipe and on the banks of the spillway discharge channel.

2. A means of upstream closure should be provided to facilitate drawdown of the reservoir and to prevent the drain pipe from being subjected to constant hydrostatic pressure. Also, access should be provided to the intake structure located in the reservoir.

3. The steep slopes in the vicinity of lake drain outlet pipe and along the spillway discharge channel should be cut back and reseeded to prevent sloughing and erosion.

4. The toe drain system should be removed and replaced at the designed elevation to enable it to function properly.

5. Deteriorated concrete should be repaired on the outlet headwall for the lake drain pipe.

6. Spalled concrete surfaces should be repaired on the Ogee spillway section at its base and its junction with the concrete discharge apron.

7. Irregular surfaces on the dam and levee should be regraded and back-filled with suitable compacted material, where necessary.

The Owner should initiate the following remedial measures:

1. Small trees and brush on both the dam and the levee, and along the banks of the outlet channels, should be removed. All resulting voids should be backfilled with suitable compacted material.

2. The sloughed area on the downstream slope of the levee should be repaired and monitored.

3. Animal burrows on the crest of the dam should be backfilled with suitable compacted material.

4. A grass cover should be established and maintained on all embankment surfaces of the dam and levee.

5. Seepage observed at the downstream toe of the dam should be monitored.

b. Operation and Maintenance Procedures

1. An operation and maintenance program should be developed and implemented. This program should include periodic operation of outlet works, routine maintenance tasks, and an annual inspection performed by a licensed professional engineer, experienced in the design and construction of dams.

2. A monitoring and downstream warning plan should be developed and implemented during periods of extreme rainfall so that downstream residents and the appropriate agencies are notified in case of an impending dam failure.



**APPENDIX A**  
**INSPECTION CHECKLIST**

CHECK LIST  
VISUAL INSPECTION  
PHASE I

Sheet 1 of 11

Name Dam N. Arrowhead Lake Dam County Monroe State PA National  
NDI ID # PA-00743

Type of Dam Earth Embankment Hazard Category Significant

Date(s) Inspection 4/08/81 Weather Clear Temperature 65 degrees F.

Pool Elevation at Time of Inspection 1668 M.S.L. Tailwater at Time of Inspection + 1652 M.S.L.

Inspection Personnel:

Lee DeHeer

Leonard Beck

Alan Hanscom

Lee DeHeer

Recorder

Remarks:

Mr. Len Tusar, General Manager for Monroe Engineering, Inc. was present during the inspection

CONCRETE/MASONRY DAMS

Sheet 2 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Not applicable	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not applicable	
DRAINS	Not applicable	
WATER PASSAGES	Not applicable	
FOUNDATION	Not applicable	

CONCRETE/MASONRY DAMS

Sheet 3 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not applicable	
STRUCTURAL CRACKING	Not applicable	
VERTICAL AND HORIZONTAL ALIGNMENT	Not applicable	
MONOLITH JOINTS	Not applicable	
CONSTRUCTION JOINTS	Not applicable	

EMBANKMENT  
(NORTH ARROWHEAD LEVEE)

Sheet 4A of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed. However, animal burrows were noted on the crest and d/s slope.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Erosion of u/s face near the water surface, due to wave action (Photo 20 Appendix C) Sloughing of embankment near 10-inch diameter standpipe (photo 19) Erosion on crest of dam (photo 16)	Provide riprap protection along u/s face. Fill and re-seed sloughed areas Provide grass cover on dam crest and discourage traffic over dam.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The east side of the dam is generally lower than the west side elevation. In particular, the access road to the east of the east side dam abutment is low (see sheet 11B)	The top of the dam could be raised to design elevation 1674, but it is not essential to the safety of the dam.
RIPRAP FAILURES	Not applicable	Riprap should be provided on u/s face, as recommended above.

EMBANKMENT

(NORTH ARROWHEAD DAM)

Sheet 4 B of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
<u>SURFACE CRACKS</u>	None observed	
<u>UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE</u>	None observed	
<u>SLOUGHING OR EROSION OF EMBANKMENT AND ADJUTMENT SLOPES</u>	Erosion and rutting observed on crest of dam due to vehicular traffic. (photo 2, Appendix C) Also, the upstream face of the dam (particularly near the gatehouse) is eroded where the riprap is missing. Sloughing observed on steep banks surrounding the headwall at the low level outlet.	Replace missing riprap and supplement existing riprap, where necessary. Fill and reseed eroded areas on crest and upstream slope. Flatten and reseed slopes surrounding headwall of low level outlet.
<u>VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST</u>	As illustrated on sheet 11c, the dam is up to 1.4 feet lower than the design elevation of 1674 in some locations.	Top of dam could be raised to design elevation 1674, but it is not essential to the safety of the dam.
<u>RIPRAP FAILURES</u>	Several areas were observed along the u/s dam face to have missing and/or displaced riprap.	Replace and repair riprap, as recommended above.

EMBANKMENT

(NORTH ARROWHEAD LEVEE)

Sheet 5A of 11

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

JUNCTION OF EMBANKMENT  
AND ABUTMENT, SPILLWAY  
AND DAM

East side abutment area is lower than much  
of the dam (see sheet 11B)

Abutment area could  
be raised, but it is not  
essential to the safety of  
the dam.

ANY NOTICEABLE SEEPAGE

None observed; however, d/s area is wet.

STAFF GAGE AND RECORDER

Not applicable

DRAINS

None observed

EMBANKMENT

(NORTH ARROWHEAD DAM)

Sheet 5 B of 11

VISUAL EXAMINATION OF

OBSERVATIONS

REMARKS OR RECOMMENDATIONS

JUNCTION OF EMBANKMENT  
AND ABUTMENT, SPILLWAY  
AND DAM

Low areas were observed near the west side  
abutment and on either side of the spillway  
inlet (see sheet 11C)

Low areas could be raised to  
design elevation, but it is  
not essential to the safety of  
the dam.

ANY NOTICEABLE SEEPAGE

Minor seepage (<1 gpm) was observed just down-  
stream of the toe drain pipe at the locations  
indicated on sheet 11 A. (see photo 10).

Toe drain pipe should be  
replaced at proper elevation  
to intercept such flow.

STAFF GAGE AND RECORDER

Not applicable

DRAINS

4-inch diameter toe drains appear to be  
installed improperly. No flow was observed  
at point of discharge to outlet channel, (see photos 10 and 11, Appendix C)

Replace toe drain system.



OUTLET WORKS  
(NORTH ARROWHEAD LEVEE)

Sheet 6A of 11

<u>VISUAL EXAMINATION OF</u>	<u>OBSERVATIONS</u>	<u>REMARKS OR RECOMMENDATIONS</u>
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not applicable	
INTAKE STRUCTURE	10-inch diameter standpipe (see photo 17, Appendix C)	
OUTLET STRUCTURE	Not applicable	
OUTLET CHANNEL	Swamp area just upstream of beach on Arrowhead Lake. Minor brush and small trees.	
EMERGENCY GATE	Not applicable	

OUTLET WORKS

(NORTH ARROWHEAD DAM).

Sheet 6 B of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Unable to observe	
INTAKE STRUCTURE	Good condition, as viewed from embankment. No access is available.	Provide access for operation of low level intake valve.
OUTLET STRUCTURE	Concrete headwall at outlet of low level drain is deteriorated and has exposed rebar.	Repair concrete headwall.
OUTLET CHANNEL	Few small trees and brush. No riprap protection. Standing water. (see sheet 11)	Provide channel protection and/or energy dissipator at low level outlet. Keep channel clear of all trees, brush and debris.
EMERGENCY GATE	20-inch gate valve at discharge of low level outlet has not been operated for years. The intake gate was submerged at time of inspection.	Exercise all outlet valves.

UNIGATED SPILLWAY  
(NORTH ARROWHEAD DAM)

Sheet 7 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Ogee section appears to be very steep and minor spalling was observed, but it is in good condition.	Repair spalled concrete near base of ogee section.
APPROACH CHANNEL	Not applicable	
DISCHARGE CHANNEL	The side slopes of the discharge channel are very steep near the spillway outlet. No riprap was installed; consequently, the slopes have sloughed and eroded. Brush and small tress line the channel banks.	The channel side slopes near the spillway should be laid back and reseeded. Brush and trees should be removed from channel banks
BRIDGE AND PIERS	Not applicable	

GATED SPILLWAY

Sheet 8 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable	
APPROACH CHANNEL	Not applicable	
DISCHARGE CHANNEL	Not applicable	
BRIDGE AND PIERS	Not applicable	
GATES AND OPERATION EQUIPMENT	Not applicable	

INSTRUMENTATION

Sheet 9 of 11

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	Not applicable	
OBSERVATION WELLS	Not applicable	
WEIRS	Not applicable	
PIEZOMETERS	Not applicable	
OTHER	Not applicable	

RESERVOIR

Sheet 10 of 11

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SLOPES

Reservoir slopes appear to be flat and well-covered with vegetation (deciduous trees, primarily). Homes around the lake appear to be above maximum flood stage.

SEDIMENTATION

No evidence of excessive sedimentation was observed.

DOWNSTREAM CHANNEL

Sheet 11 of 11	
VISUAL EXAMINATION OF	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	
The downstream channel has a few small obstructions, including rocks, sloughed areas, etc.	Channel should be cleared of obstructions and regraded to promote better drainage of local runoff.

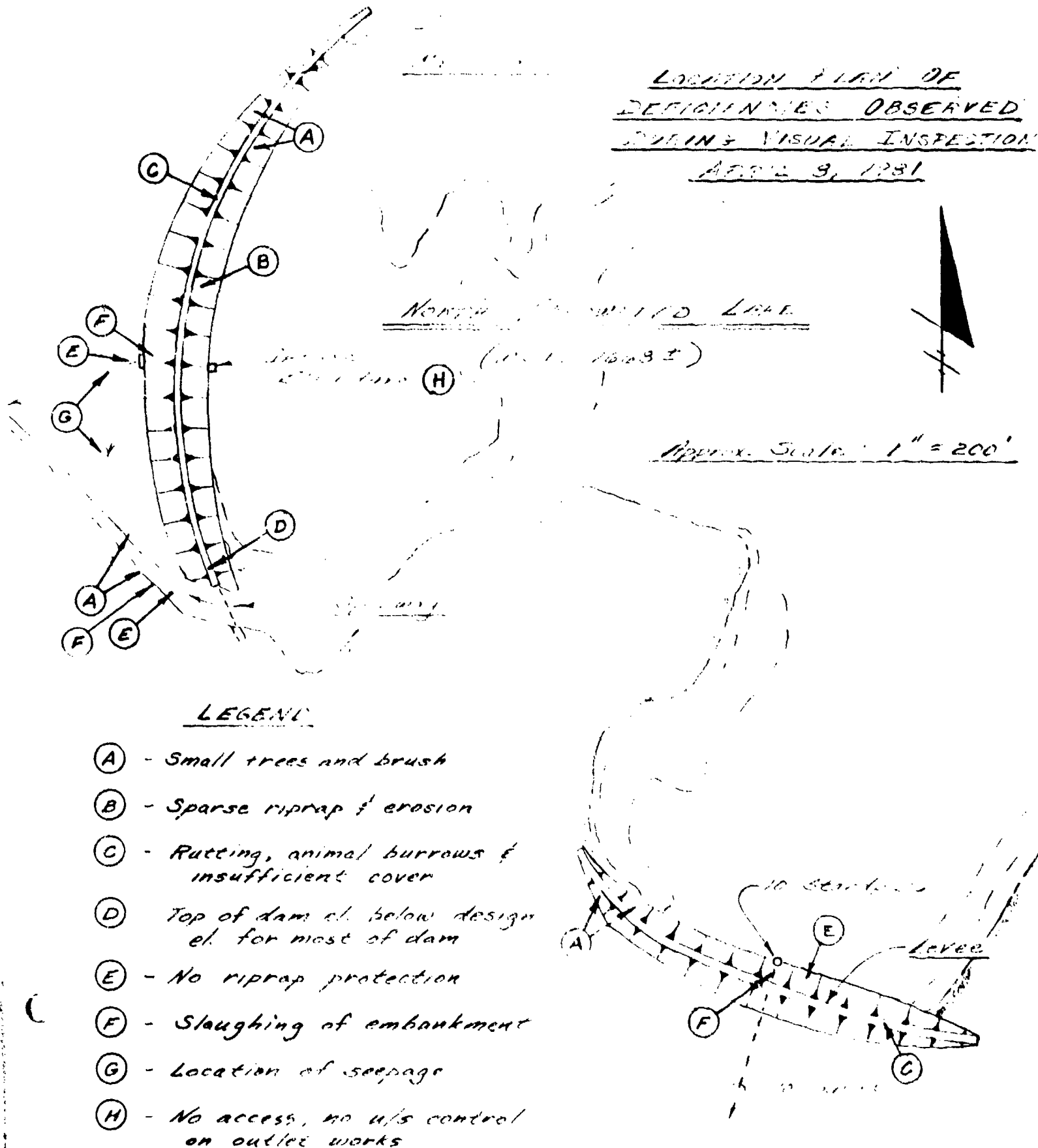
SLOPES

The channel slope is mild, but adequate.

APPROXIMATE NO.  
OF HOMES AND  
POPULATION

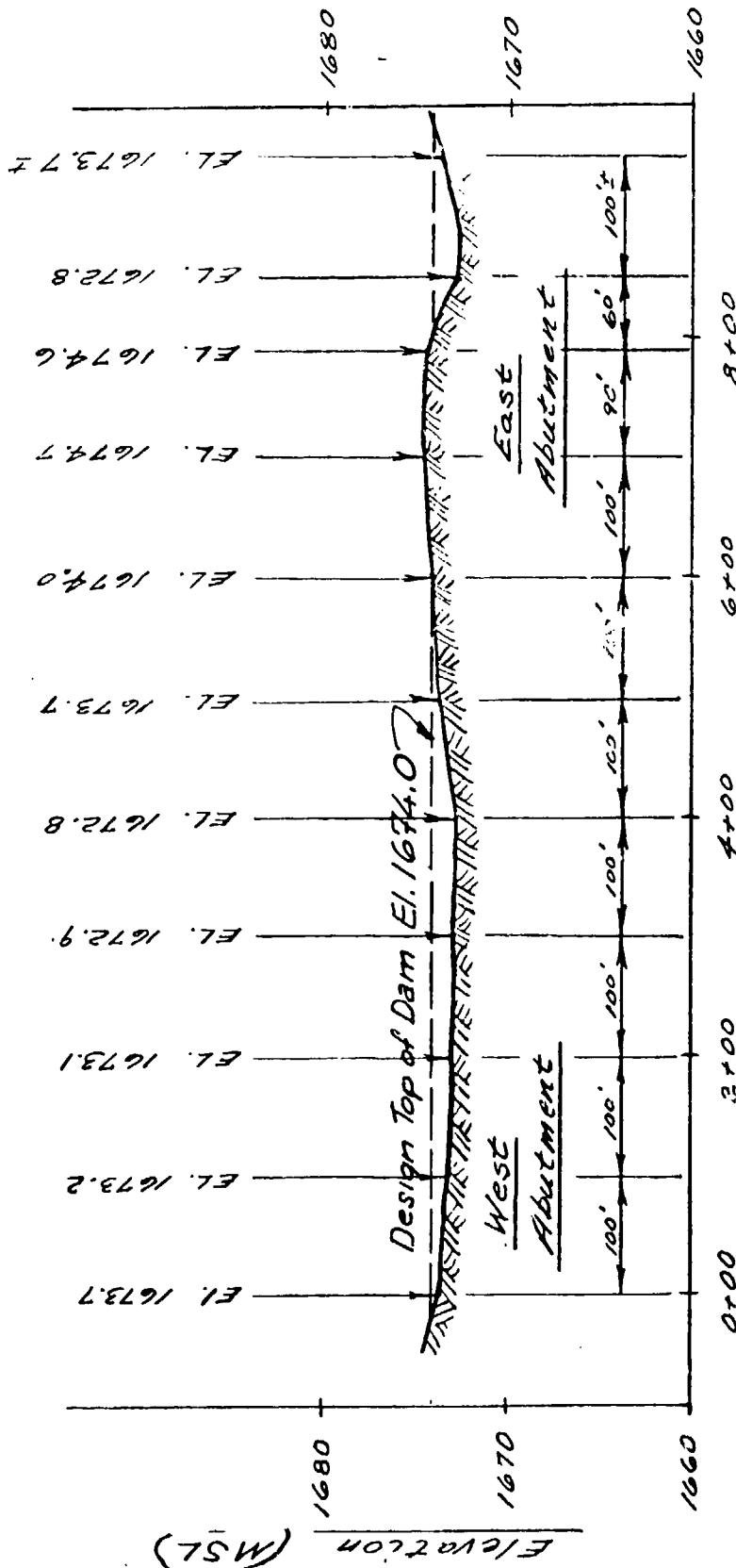
There is a small fire station, housing two fire engines, approximately 350 feet d/s of the dam. Also, there are several residences (8-10) along Arrowhead Lake. (1st floor E1. 1656±)

SUBJECT	SHEET	BY	DATE	JOB NO.
4th Co. Arroyo	110	11	11-1-81	431,010





SUBJECT	SHEET	BY	DATE	JOB NO.
Profile: N. Arrowhead Lake Levee (East Side)	11B	ADH	4-30-81	1841.014



Scales: Hor. 1" = 300'  
Vert. 1" = 10'

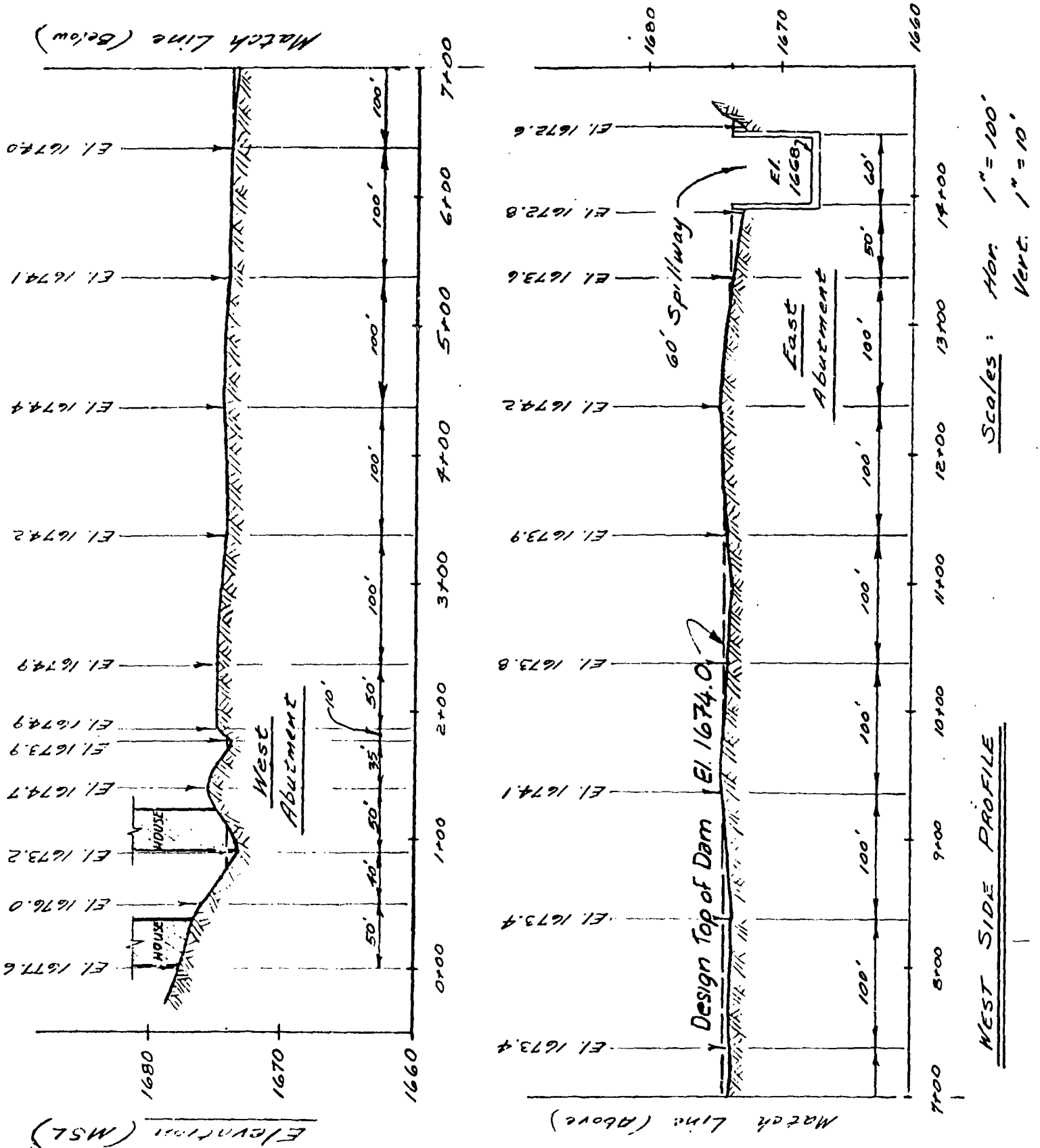
**EAST SIDE PROFILE**

**NOTE:**

A 10-inch diameter intake pipe is located approximately 420 feet from the right side abutment. (See Photo 17, Appendix C.)

SUBJECT	SHEET	BY	DATE	JOB NO
Profile: N. Arrowhead Lake Dam	11C	ADH	4-30-81	1841.014

(West Side.)



APPENDIX B  
CHECKLIST  
ENGINEERING DATA

O'BRIEN & GERE

NAME OF DAM N. Arrowhead Lake Dam  
 NDIL # PA-00743

Sheet 1 of 4

CHECK LIST  
 ENGINEERING DATA  
 DESIGN, CONSTRUCTION, OPERATION  
 PHASE I

ITEM

REMARKS

AS-BUILT DRAWINGS

None Available

REGIONAL VICINITY MAP

See Figure 1, Appendix E.

CONSTRUCTION HISTORY

The dam was constructed in 1970 by G.H. Litts, Inc.; Marshalls Creek, PA. The only known work performed since the original construction took place in 1972 when riprap was added to the upstream face of the dam.

TYPICAL SECTIONS OF DAM

See sheets 3 & 4, Appendix E.

OUTLETS - PLAN

DETAILS

CONSTRAINTS

See sheets 5 & 6, Appendix E.

DISCHARGE RATINGS

None Available

RAINFALL/RESERVOIR RECORDS

None Available

ITEM	REMARKS
DESIGN REPORTS	None Available
GEOLOGY REPORTS	None Available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Design data is available from Monroe Engineering, Inc.; East Stroudsburg, PA.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY } FIELD }	Post-construction borings and materials testing were performed by Geo-Surveys; Camp Hill, PA.
POST-CONSTRUCTION SURVEYS OF DAM	None Available
BORROW SOURCES	Lake bottom

Sheet 3 of 4

ITEM	REMARKS
MONITORING SYSTEMS	Dam monitored by Development Security Personnel.
MODIFICATIONS	Riprap added to upstream dam face in 1972.
HIGH POOL RECORDS	None Available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Borings and materials testing per DER request.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	None available

ITEM	REMARKS
<div> <div>SPILLWAY PLAN</div> <div> <div>SECTIONS</div> <div>DETAILS</div> </div> </div>	See sheet 5, Appendix E.
OPERATING EQUIPMENT PLANS & DETAILS	Not applicable
MISCELLANEOUS	Refer to Section 2

Note: Information presented on this checklist was obtained from  
Mr. Len Tusar, General Manager for Monroe Engineering, Inc.

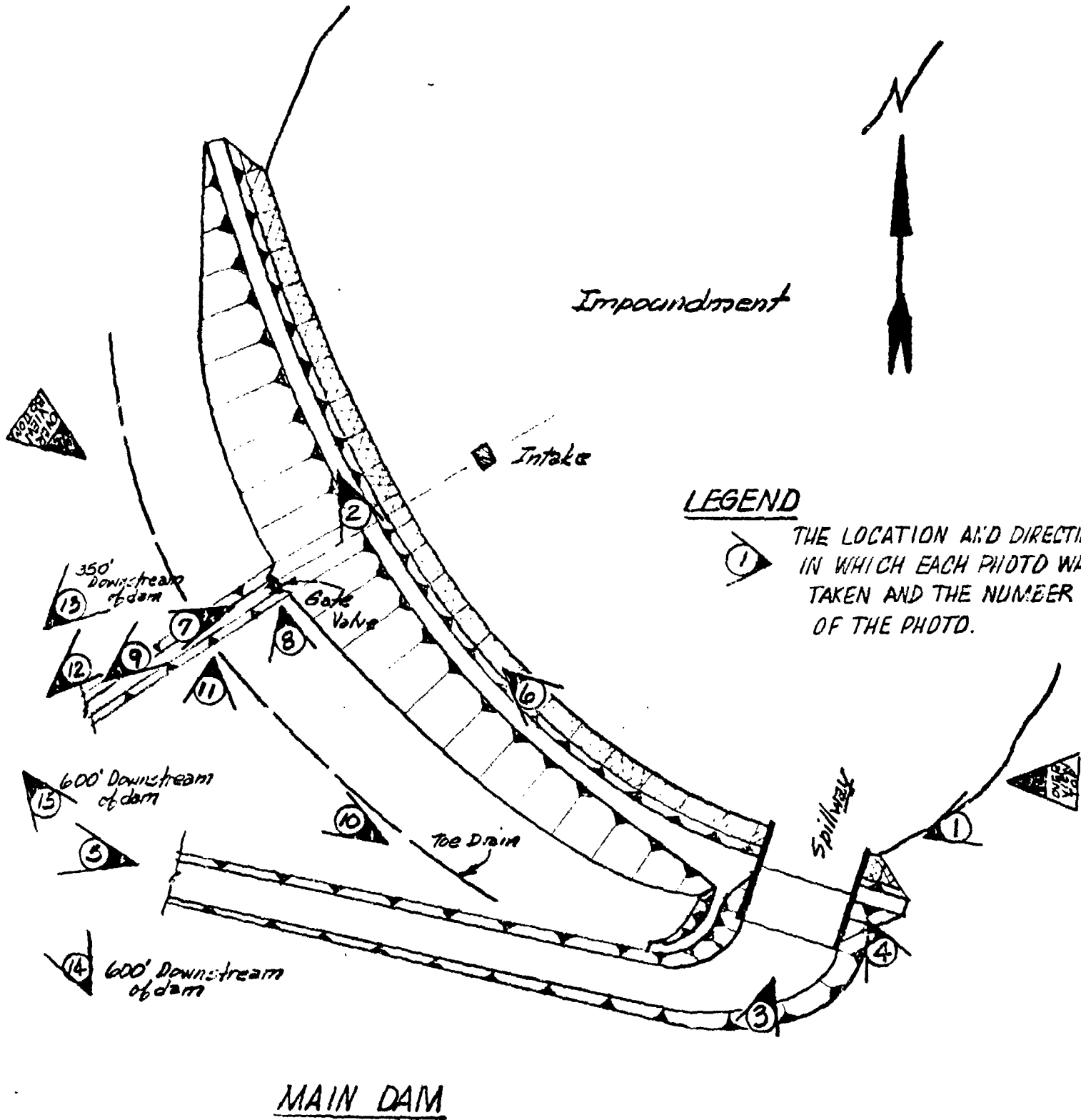
APPENDIX C  
PHOTOGRAPHS



APPENDIX C  
PHOTOGRAPH TABLE OF CONTENTS

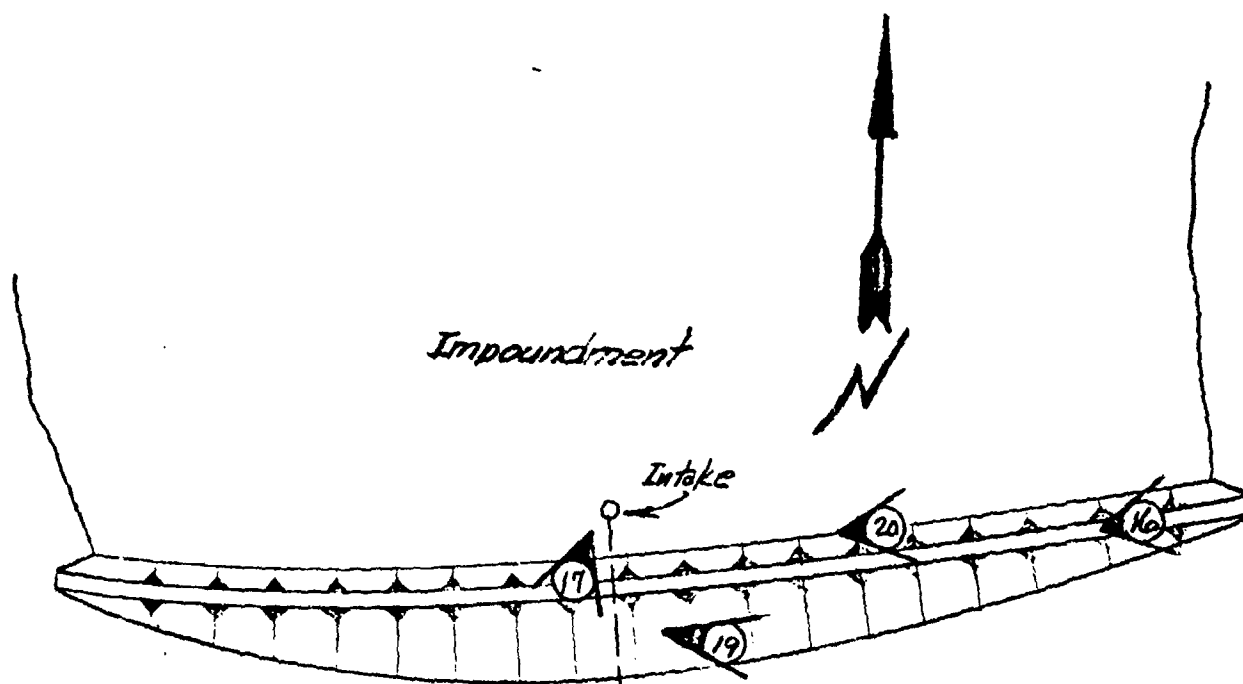
	<u>Page No.</u>
Site Plan	A-A <sub>1</sub>
<u>PHOTOGRAPH</u>	
<u>No.</u>	
1. View along the centerline of the dam from the left spillway sidewall. (4/8/81)	1
2. View along the centerline of the dam from near the right abutment. (4/8/81)	1
3. Spillway looking upstream. (4/8/81)	2
4. Embankment situation next to the left spillway sidewall. (4/8/81)	2
5. Spillway discharge channel. (4/8/81)	3
6. Typical small trees and brush growing on the dam. (4/8/81)	3
7. Valve for reservoir drain. (4/8/81)	4
8. Reservoir drain valve and deteriorated reinforced concrete mounting. (4/8/81)	4
9. Reservoir drain outlet channel. (4/8/81)	5
10. Seepage near the downstream toe about 300 feet right of the left abutment. (4/8/81)	5
11. Outlet for embankment under drain pipe. (4/8/81)	6
12. Twin 36-inch diameter culverts about 400 feet downstream of the dam. (4/8/81)	6
13. Fire house about 350 feet downstream of the dam. (4/8/81)	7
14. Homes about 600 feet downstream of the dam on the shores of Arrowhead Lake. (4/8/81)	7
15. Homes on the shores of Arrowhead Lake. On the right, the discharge from North Arrowhead Lake enters Arrowhead Lake. (4/8/81)	8
16. View along the centerline of the North Arrowhead Levee which is about 1,000 feet east of North Arrowhead Dam. (4/8/81)	8
17. Inlet structure at the North Arrowhead levee. (4/8/81)	9
18. Outlet downstream of the North Arrowhead levee. (4/8/81)	9
19. Displaced embankment on the North Arrowhead levee. (4/8/81)	10
20. Eroded upstream slope on the North Arrowhead levee. (4/8/81)	10

SUBJECT	SHEET	BY	DATE	JOB NO.
North Arrowhead Lake Dam	A	E	5/26/81	184-014



**O'BRIEN & GERE**  
ENGINEERS, INC.

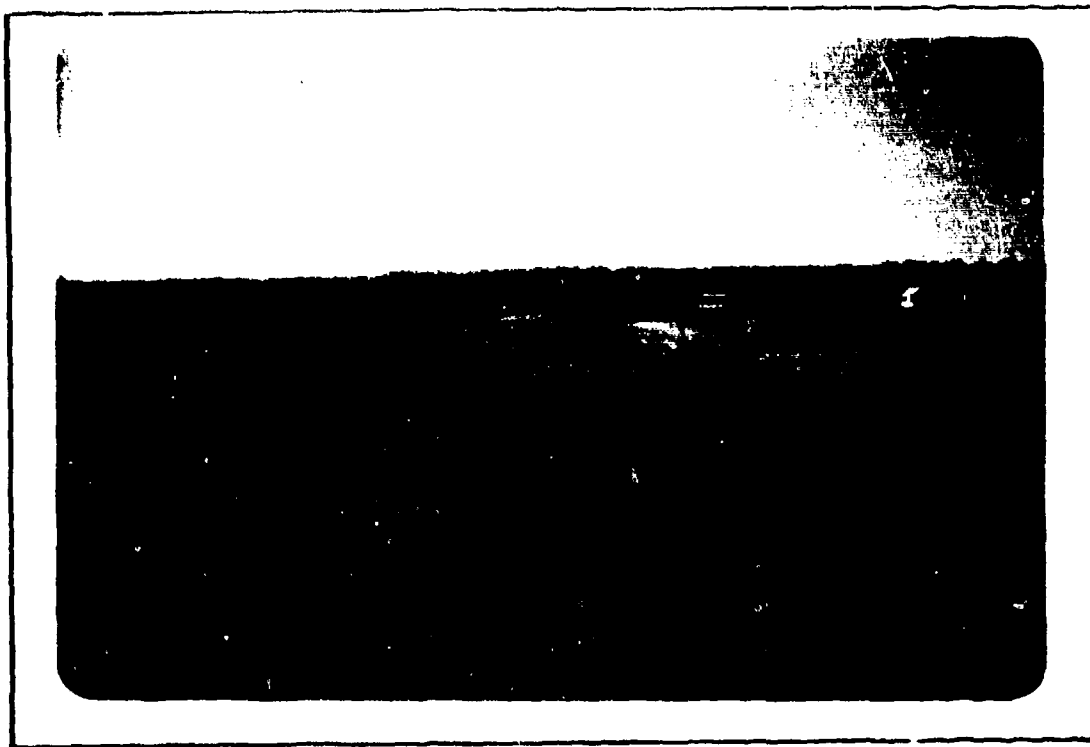
SUBJECT	SHEET	BY	DATE	JOB NO.
North Arrowhead Lake Dam	A1	JG	5/27/81	1841-014



LEGEND

(17) THE LOCATION AND DIRECTION  
IN WHICH EACH PHOTO WAS  
TAKEN AND THE NUMBER  
OF THE PHOTO.

NORTH ARROWHEAD LEVEE  
(EAST OF THE MAIN DAM)



1. VIEW ALONG THE CENTERLINE OF THE DAM FROM THE LEFT SPILLWAY  
SIDEWALL. (4/8/81)



2. VIEW ALONG THE CENTERLINE OF THE DAM FROM NEAR THE RIGHT  
ABUTMENT. (4/8/81)



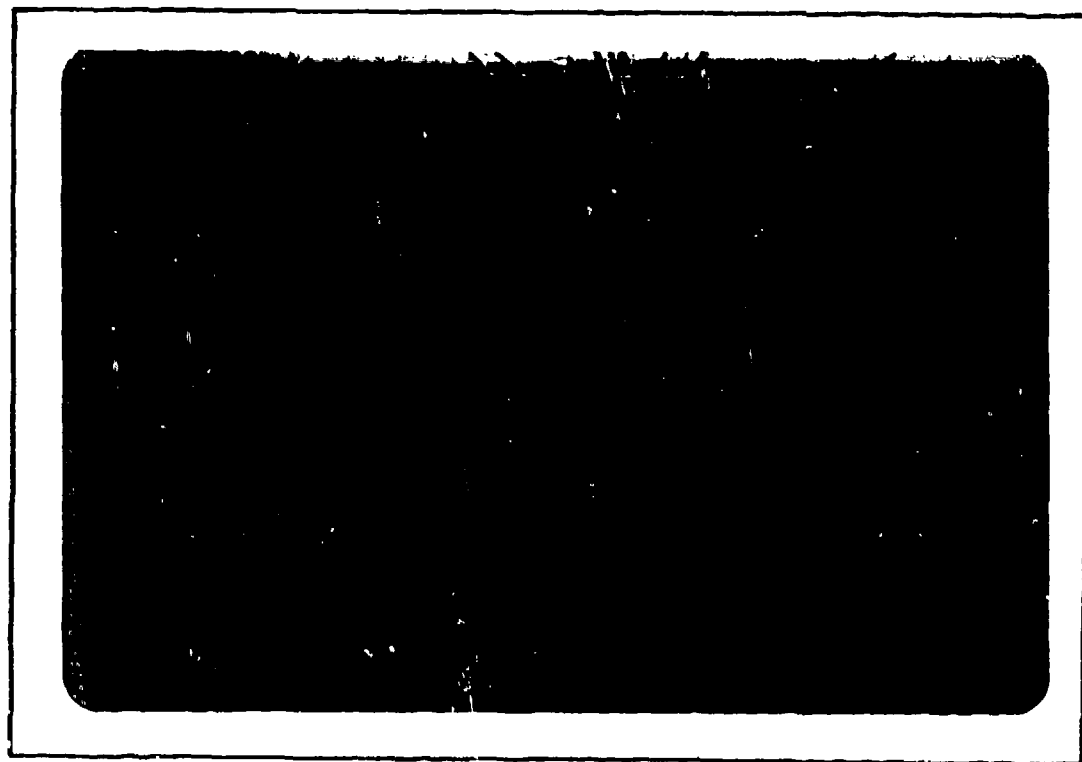
3. SPILLWAY LOOKING UPSTREAM. (4/8/81)



4. EMBANKMENT SITUATION NEXT TO THE LEFT SPILLWAY SIDEWALL.  
(4/8/81)



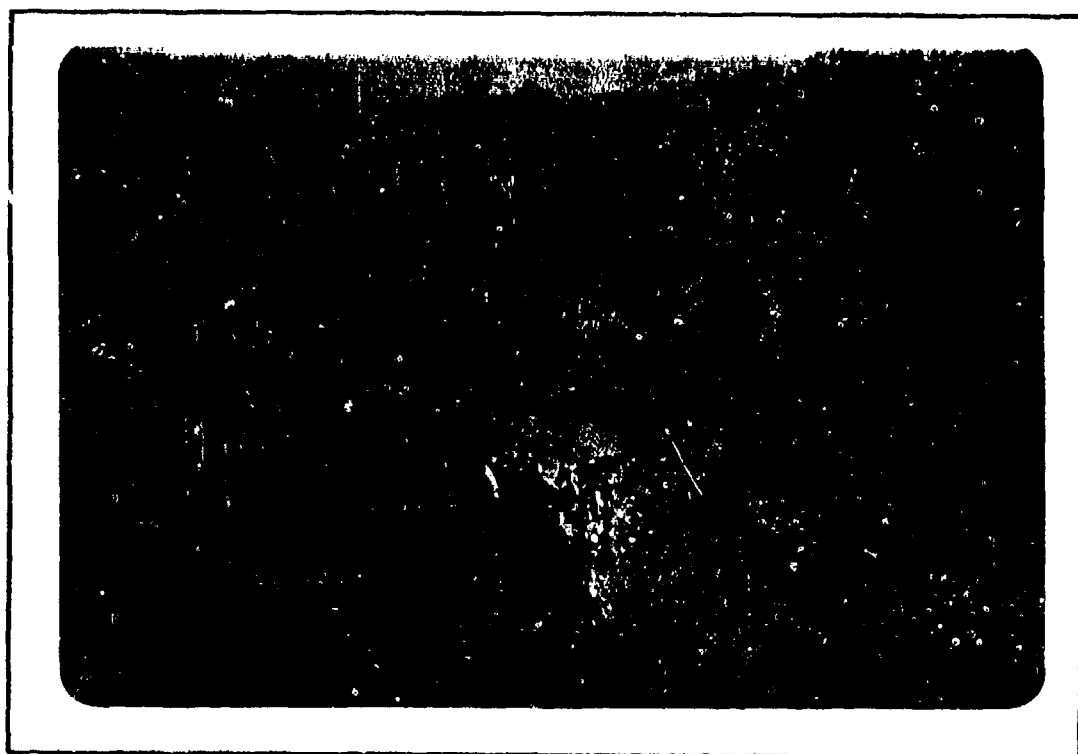
5. SPILLWAY DISCHARGE CHANNEL. (4/8/81)



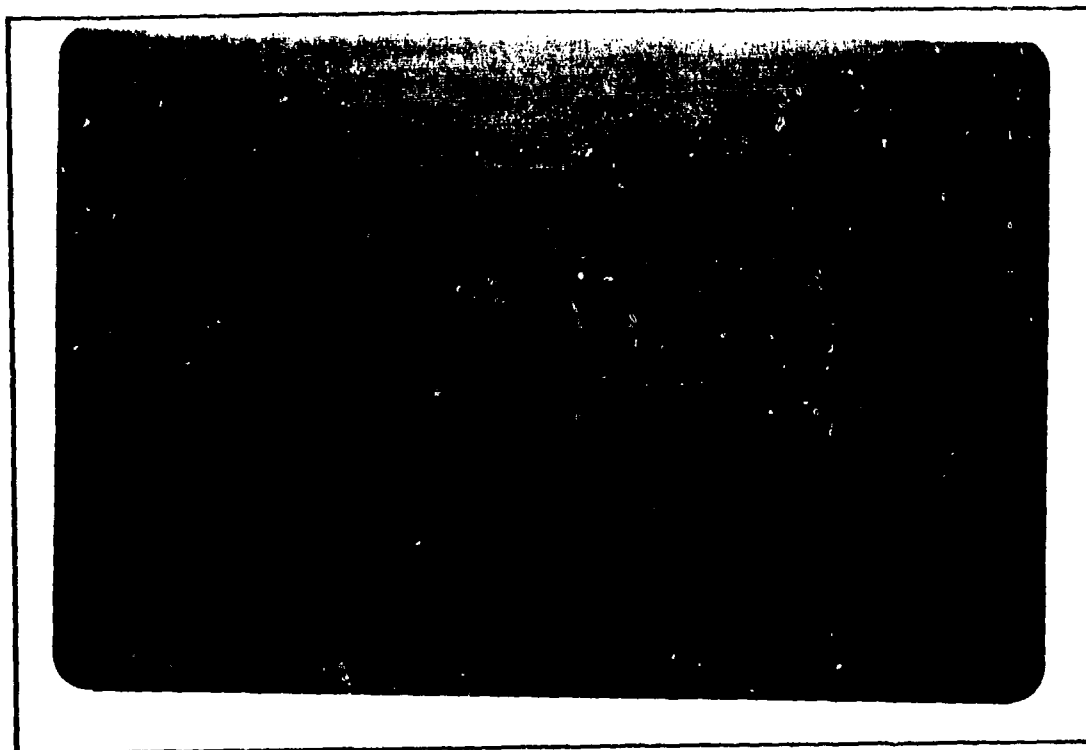
6. TYPICAL SMALL TREES AND BRUSH GROWING ON THE DAM. (4/8/81)



7. VALVE FOR RESERVOIR DRAIN. (4/8/81)



8. RESERVOIR DRAIN VALVE AND DETERIORATED REINFORCED  
CONCRETE MOUNTING. (4/8/81)



9. RESERVOIR DRAIN OUTLET CHANNEL. (4/8/81)

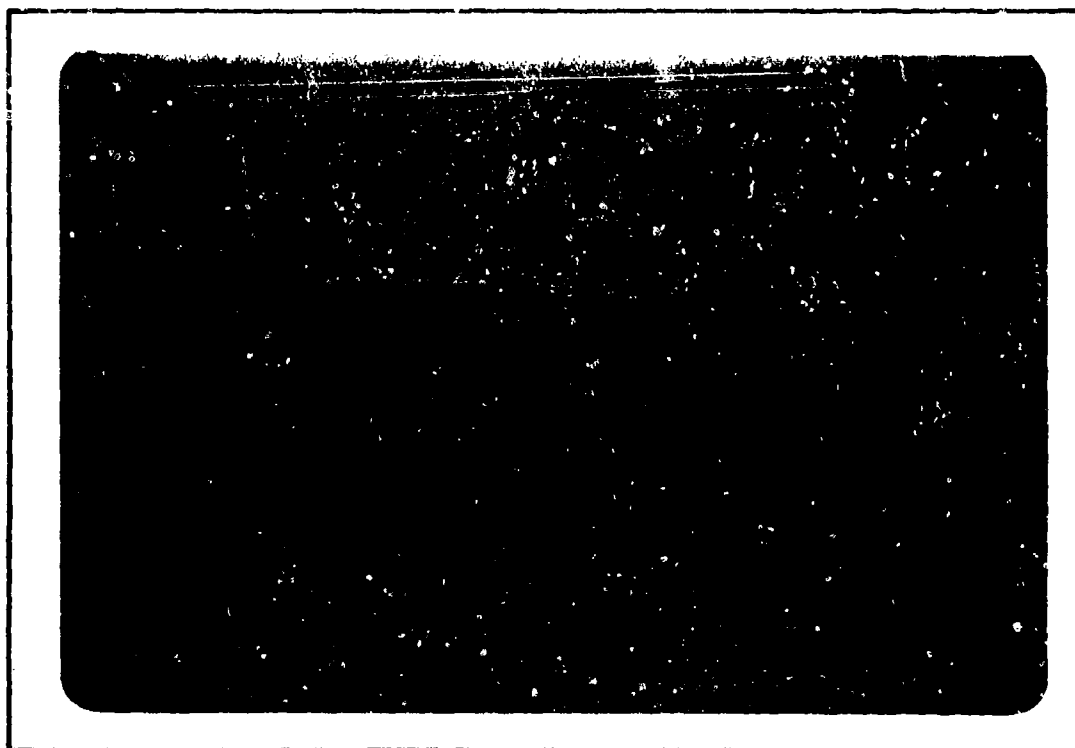


10. SEEPAGE NEAR THE DOWNSTREAM TOE ABOUT 300 FEET RIGHT OF THE LEFT ABUTMENT. (4/8/81)

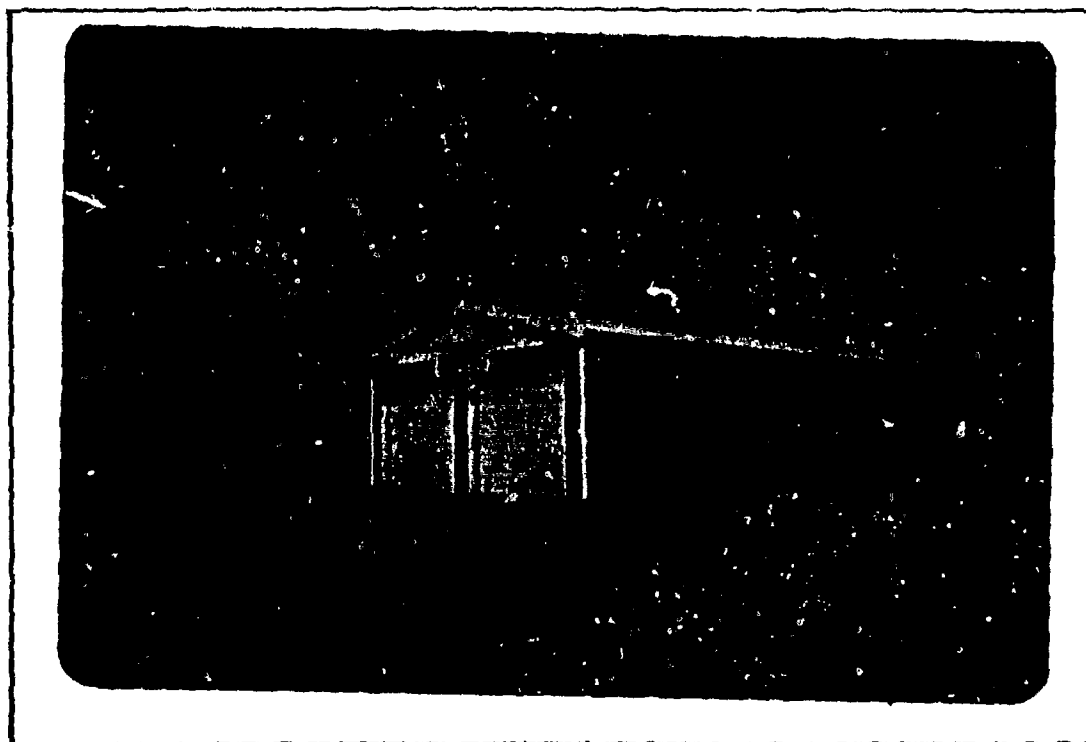




11. OUTLET FOR EMBANKMENT UNDER DRAIN PIPE. (4/8/81)



12. TWIN 36-INCH DIAMETER CULVERTS ABOUT 400 FEET DOWNSTREAM OF THE DAM. (4/8/81)



13. FIRE HOUSE ABOUT 350 FEET DOWNSTREAM OF THE DAM. (4/8/81)



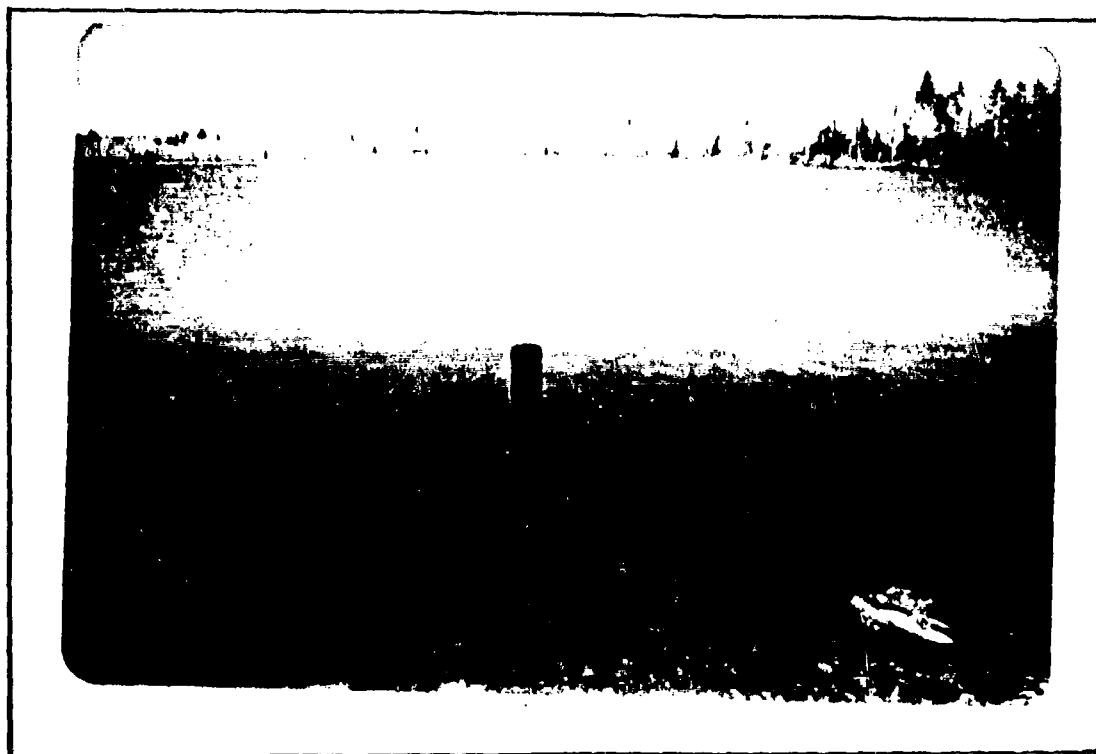
14. HOMES ABOUT 600 FEET DOWNSTREAM OF THE DAM ON THE SHORES OF ARROWHEAD LAKE. (4/8/81)



15. HOMES ON THE SHORES OF ARROWHEAD LAKE. ON THE RIGHT,  
THE DISCHARGE FROM NORTH ARROWHEAD LAKE ENTERS ARROWHEAD  
LAKE. (4/8/81)



16. VIEW ALONG THE CENTERLINE OF THE NORTH ARROWHEAD LEVEE  
WHICH IS ABOUT 1,000 FEET EAST OF NORTH ARROWHEAD DAM.  
(4/8/81)



17. INLET STRUCTURE AT THE NORTH ARROWHEAD LEVEE. (4/8/81)



18. OUTLET DOWNSTREAM OF THE NORTH ARROWHEAD LEVEE. (4/8/81)



19. DISPLACED EMBANKMENT ON THE NORTH ARROWHEAD LEVEE. (4/8/81)



20. ERODED UPSTREAM SLOPE ON THE NORTH ARROWHEAD LEVEE. (4/8/81)

APPENDIX D  
HYDROLOGIC AND HYDRAULIC  
ENGINEERING DATA

O'BRIEN & GERE

NORTH ARROWHEAD LAKE DAM

APPENDIX D

HYDROLOGIC AND HYDRAULIC  
ENGINEERING DATA

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CHECK LIST  
HYDROLOGIC AND HYDRAULIC  
ENGINEERING DATADRAINAGE AREA CHARACTERISTICS: Residential, primarily forestedELEVATION TOP NORMAL POOL (STORAGE CAPACITY): E1. 1668 (433 Ac-Ft.)ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): E1. 1672.8 (968 Ac-Ft.)ELEVATION MAXIMUM DESIGN POOL: E1. 1674ELEVATION TOP DAM: E1. 1672.8 (Low Point of Dam)

## SPILLWAY

- a. Elevation 1668.0
- b. Type Concrete Ogee
- c. Width Ogee Shaped Crest
- d. Length 60 Feet
- e. Location Spillover East Side Abutment
- f. Number and Type of Gates None

## OUTLET WORKS:

- a. Type 20-inch diameter low level outlet
- b. Location near center of dam
- c. Entrance invert 1654.0
- d. Exit invert 1653.0
- e. Emergency drawdown facilities Stoplogs & 20-inch Gate Valve

## HYDROMETEOROLOGICAL GAGES:

- a. Type None
- b. Location Not available
- c. Records Not available

MAXIMUM NON-DAMAGING DISCHARGE: Not determined



HEC-1, REVISED  
FLOOD HYDROGRAPH PACKAGE

The original "Flood Hydrograph Package" (HEC-1), developed by the Hydrologic Engineering Center, Corps of Engineers, has been modified for use under the National Dam Inspection Program. The "Flood Hydrograph Package (HEC-1), Dam Safety Version", hereinafter referred to as, HEC-1, Rev., has been modified to require less detailed input and to include a dam breach analysis. The required input is obtained from the field inspection of a dam, any available design/evaluation data, relatively simple hydraulic calculations, or information from the USGS Quadrangle maps. The input format is flexible in order to reflect any unique characteristics of an individual dam.

HEC-1, Rev. computes a reservoir inflow hydrograph based on individual watershed characteristics such as: area, percentage of impervious surface area, watershed shape, and hydrograph characteristics determined from regional correlation studies by the Corps of Engineers, Baltimore District. The inflow is routed through the reservoir using spillway discharge data obtained from the field inspection or design data. Flood storage capacity is determined from USGS maps or design information and verified by the field inspection. In the event a spillway cannot discharge 0.5 PMF without overtopping and failure of the dam, downstream channel characteristics obtained from the field inspection and USGS maps are inputted and flows are routed downstream to the damage center and a dam breach analysis is performed.

Included in this Appendix are the HEC-1, Rev. pertinent input values and a summary print-out.

*High hazard structures only*

SUBJECT	SHEET	BY	DATE	JOB NO
North Arrowhead Lake Dam	3	JG	4/3/81	1841-014

### Hydrology Calculations

Drainage Area = 1.01 mi<sup>2</sup> (Planimetered from USGS Quad. sheet)

### Surface Areas of North Arrowhead Lake

Elev.	Area (Acres)	
1653	0	Front longitudinal embankment sections dregs
1668	86.5	Normal Pool
1673	129	Top of Dam

### PMP Calculations (HMR 33)

Area is in Zone 6  
24 hr, 200 mi<sup>2</sup> rainfall = 22.7"

Hr.	%	Rainfall (inches)	$\Delta$ Rainfall (inches)
6	113	25.7	25.7
12	123	27.9	2.2
24	132	30.0	2.1
48	142	32.3	2.3

### Snyder Coefficients (Information provided by Batt. COE)

Area is in Zone 2

$C_p = 0.45$ ,  $L = 1.27$  mi,  $L_{ca} = 1.12$  mi

$C_x = 2.1$

$$T_p = C_x (L \cdot L_{ca})^{0.3}$$

$$T_p = 2.1 (1.27 \cdot 1.12)^{0.3}$$

$$T_p = 2.33 \text{ hr.}$$

SUBJECT	SHEET	BY	DATE	JOB NO
North Arrowhead Lake Dam	4	ADH	4-30-81	1841.014

Stage - Discharge Calculations:

- 1.) Flow over spillway  $\rightarrow Q_s = C L_s H_s^{3/2}$ ; where  $C \approx 3.5$   
for ogee  $\&$   $L_s = 60$  feet
- 2.) Flow over dam  $\rightarrow Q_D = C L_D H_D^{3/2}$ ; where  $C \approx 3.0$   
for short broad-crested weir  $\&$   $L_D$  varies  
per dam profiles
- 3.) Flow over abutments  $\rightarrow Q_A = C L_A H_A^{3/2}$ ; where  $C \approx 2.8$   
for long broad-crested weir  $\&$   $L_A$  varies

Stage - Discharge Table:

Elev. (MSL)	$H_s$ (feet)	$Q_s$ (cfs)	$H_D$ (feet)	$L_D$ (feet)	$Q_D$ (cfs)	$H_A$ (feet)	$L_A$ (feet)	$Q_A$ (cfs)	$Q_{Total}$ (cfs)
1668	0	0	—	—	—	—	—	—	0
1669	1.0	210	—	—	—	—	—	—	210
1670	2.0	594	—	—	—	—	—	—	594
1671	3.0	1,091	—	—	—	—	—	—	1,091
1672	4.0	1,680	—	—	—	—	—	—	1,680
1672.8*	4.8	2,208	0	0	0	—	—	—	2,208
1673	5.0	2,348	0.1	180	17	—	—	—	2,365
1674	6.0	3,086	0.55	1,420	1,738	0.5	250	247	5,071
1675	7.0	3,889	1.2	2,050	8,084	0.8	600	1,202	13,175

\* Low point of dam crest



O'BRIEN & GERE

SUBJECT

North Arrowhead Lake Dam

SHEET

5

BY

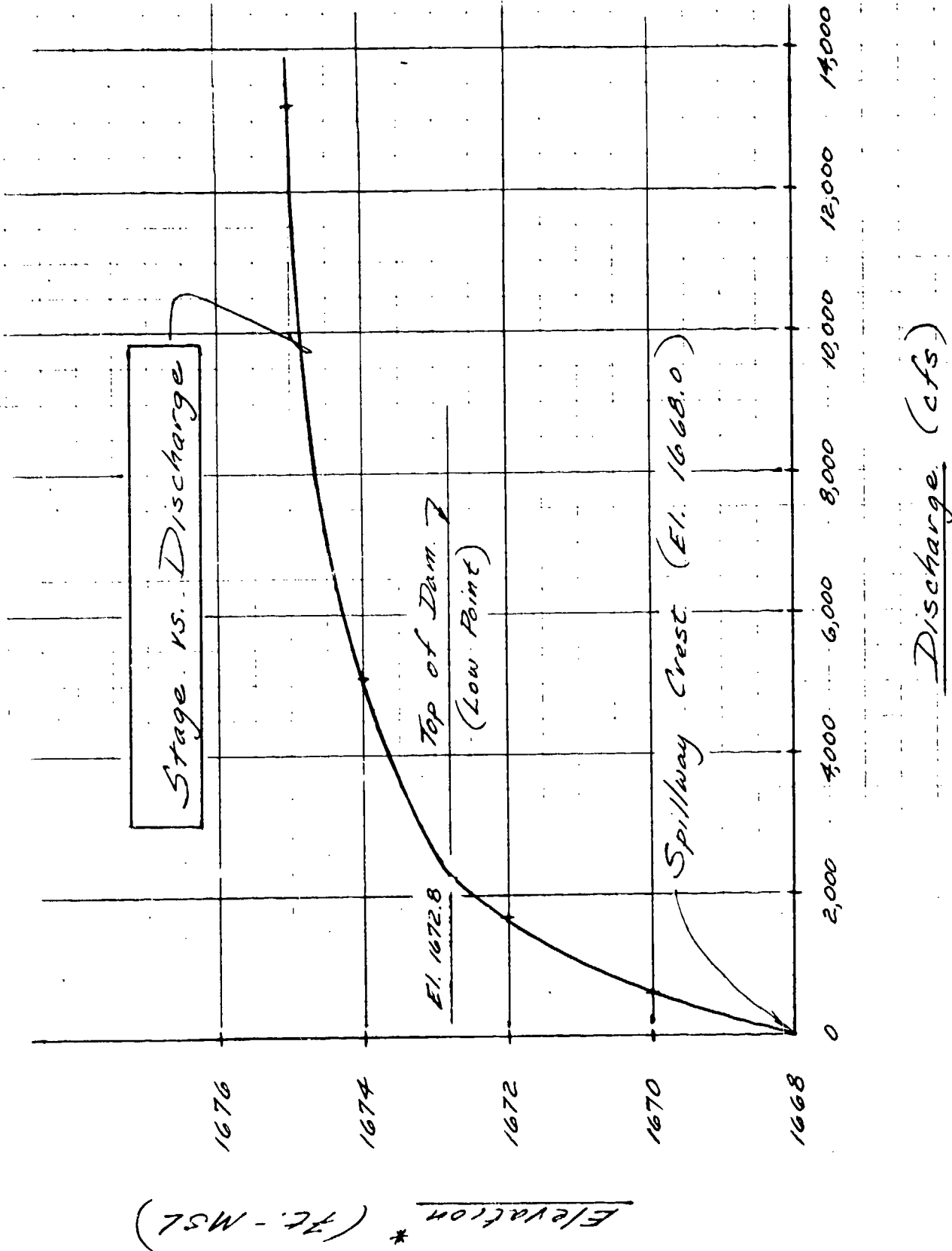
ADH

DATE

5-04-81

JOB NO

1841.014



\* Note: Spillway crest elevation assumed to be El. 1668 to be consistent with Arrowhead Lake Report.

1\*\*\*\*\*  
 FLOOD HYDROGRAPH PACKAGE (HEC-1)  
 DAM SAFETY VERSION JULY 1978  
 LAST MODIFICATION 01 APR 80  
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NATIONAL DAM INSPECTION PROGRAM BALTIMORE CORPS OF ENGINEERS NORTH ARROWHEAD LAKE DAM									
1	300	0	10	0	0	0	0	-4	0
2	5	9	1						
3	1	.2	.3	.4	.5	.6	.7	.8	1.0
4	0	INFLOW							
5	1	1	1						
6	0	22.7	113	123	132	142	1	.05	
7	0	2.3	0.45						
8	0	-1.5	-0.5						
9	1	OUTFLOW							
10	1	1							
11	0	22.7	113	123	132	142	1	.05	
12	0	2.3	0.45						
13	0	-1.5	-0.5						
14	1	OUTFLOW							
15	1	1							
16	0	22.7	113	123	132	142	1	.05	
17	0	2.3	0.45						
18	0	-1.5	-0.5						
19	1	OUTFLOW							
20	1	1							
21	0	22.7	113	123	132	142	1	.05	
22	0	2.3	0.45						
23	0	-1.5	-0.5						
24	1	OUTFLOW							
25	1	1							

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT INFLOW  
 ROUTE HYDROGRAPH TO OUTFLOW  
 END OF NETWORK

NATIONAL DAM INSPECTION PROGRAM  
 BALTIMORE CORPS OF ENGINEERS  
 NORTH ARROWHEAD LAKE DAM

JOB SPECIFICATION									
NR	NHR	NMIN	IDAY	IHR	IMIN	METRC	IFLT	IFRT	INSTAN
300	0	10	0	0	0	0	0	-4	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED

RT105= .10 .20 .30 .40 .50 .60 .70 .80 1.00  
 NPLAN= 1 NR10= 9 LR10= 1

sh 6

# SUB-AREA RUNOFF COMPUTATION

RUNOFF TO NORTH ARROWHEAD LAKE

ISTAD IFOMF IECON ITAFE JPLI JFRT INAME ISTAR IAUTO  
INFLOW 0 0 0 0 0 1 0 0

IHYDG IUNG TAREA SNAP TRSDA TRSFC RATIO ISNOW ISAME LOCAL

1 1 1.00 0.00 1.00 0.00 0.000 0 0 0

PRECIP IATA R6 R12 R24 R48 R72 R96

0.00 22.70 113.00 123.00 132.00 142.00 0.00 0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

## LOSS DATA

LRDPT STNR DLTR RTIOL ERAIN STFNG RTIOK STRIL CNSTL ALSHX RTIME  
0 0.00 0.00 1.00 0.00 0.00 1.00 1.00 .05 0.00 0.00

## UNIT HYDROGRAPH DATA

CP= .45 NIA= 0

STRIN= -1.50 R100= 2.00

UNIT HYDROGRAPH100 END-OF-PERIOD ORIGINATES, LAG= 2.30 HOURS, CP= .45 VOL= 199

MO.DA	MP.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	END-OF-PERIOD FLOW	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
2.	116.	124.	128.	130.	132.	134.	136.	138.	140.	142.	144.	146.	148.	150.
9.	124.	128.	130.	132.	134.	136.	138.	140.	142.	144.	146.	148.	150.	152.
16.	128.	130.	132.	134.	136.	138.	140.	142.	144.	146.	148.	150.	152.	154.
23.	130.	132.	134.	136.	138.	140.	142.	144.	146.	148.	150.	152.	154.	156.
30.	132.	134.	136.	138.	140.	142.	144.	146.	148.	150.	152.	154.	156.	158.
6.	134.	136.	138.	140.	142.	144.	146.	148.	150.	152.	154.	156.	158.	160.
13.	136.	138.	140.	142.	144.	146.	148.	150.	152.	154.	156.	158.	160.	162.
20.	138.	140.	142.	144.	146.	148.	150.	152.	154.	156.	158.	160.	162.	164.
27.	140.	142.	144.	146.	148.	150.	152.	154.	156.	158.	160.	162.	164.	166.
3.	142.	144.	146.	148.	150.	152.	154.	156.	158.	160.	162.	164.	166.	168.
10.	144.	146.	148.	150.	152.	154.	156.	158.	160.	162.	164.	166.	168.	170.
17.	146.	148.	150.	152.	154.	156.	158.	160.	162.	164.	166.	168.	170.	172.
24.	148.	150.	152.	154.	156.	158.	160.	162.	164.	166.	168.	170.	172.	174.
31.	150.	152.	154.	156.	158.	160.	162.	164.	166.	168.	170.	172.	174.	176.
7.	152.	154.	156.	158.	160.	162.	164.	166.	168.	170.	172.	174.	176.	178.
14.	154.	156.	158.	160.	162.	164.	166.	168.	170.	172.	174.	176.	178.	180.
21.	156.	158.	160.	162.	164.	166.	168.	170.	172.	174.	176.	178.	180.	182.
28.	158.	160.	162.	164.	166.	168.	170.	172.	174.	176.	178.	180.	182.	184.
4.	160.	162.	164.	166.	168.	170.	172.	174.	176.	178.	180.	182.	184.	186.
11.	162.	164.	166.	168.	170.	172.	174.	176.	178.	180.	182.	184.	186.	188.
18.	164.	166.	168.	170.	172.	174.	176.	178.	180.	182.	184.	186.	188.	190.
25.	166.	168.	170.	172.	174.	176.	178.	180.	182.	184.	186.	188.	190.	192.
3.	168.	170.	172.	174.	176.	178.	180.	182.	184.	186.	188.	190.	192.	194.
10.	170.	172.	174.	176.	178.	180.	182.	184.	186.	188.	190.	192.	194.	196.
17.	172.	174.	176.	178.	180.	182.	184.	186.	188.	190.	192.	194.	196.	198.
24.	174.	176.	178.	180.	182.	184.	186.	188.	190.	192.	194.	196.	198.	200.
31.	176.	178.	180.	182.	184.	186.	188.	190.	192.	194.	196.	198.	200.	202.
7.	178.	180.	182.	184.	186.	188.	190.	192.	194.	196.	198.	200.	202.	204.
14.	180.	182.	184.	186.	188.	190.	192.	194.	196.	198.	200.	202.	204.	206.
21.	182.	184.	186.	188.	190.	192.	194.	196.	198.	200.	202.	204.	206.	208.
28.	184.	186.	188.	190.	192.	194.	196.	198.	200.	202.	204.	206.	208.	210.
4.	186.	188.	190.	192.	194.	196.	198.	200.	202.	204.	206.	208.	210.	212.
11.	188.	190.	192.	194.	196.	198.	200.	202.	204.	206.	208.	210.	212.	214.
18.	190.	192.	194.	196.	198.	200.	202.	204.	206.	208.	210.	212.	214.	216.
25.	192.	194.	196.	198.	200.	202.	204.	206.	208.	210.	212.	214.	216.	218.
31.	194.	196.	198.	200.	202.	204.	206.	208.	210.	212.	214.	216.	218.	220.
7.	196.	198.	200.	202.	204.	206.	208.	210.	212.	214.	216.	218.	220.	222.
14.	198.	200.	202.	204.	206.	208.	210.	212.	214.	216.	218.	220.	222.	224.
21.	200.	202.	204.	206.	208.	210.	212.	214.	216.	218.	220.	222.	224.	226.
28.	202.	204.	206.	208.	210.	212.	214.	216.	218.	220.	222.	224.	226.	228.
4.	204.	206.	208.	210.	212.	214.	216.	218.	220.	222.	224.	226.	228.	230.
11.	206.	208.	210.	212.	214.	216.	218.	220.	222.	224.	226.	228.	230.	232.
18.	208.	210.	212.	214.	216.	218.	220.	222.	224.	226.	228.	230.	232.	234.
25.	210.	212.	214.	216.	218.	220.	222.	224.	226.	228.	230.	232.	234.	236.
31.	212.	214.	216.	218.	220.	222.	224.	226.	228.	230.	232.	234.	236.	238.
7.	214.	216.	218.	220.	222.	224.	226.	228.	230.	232.	234.	236.	238.	240.
14.	216.	218.	220.	222.	224.	226.	228.	230.	232.	234.	236.	238.	240.	242.
21.	218.	220.	222.	224.	226.	228.	230.	232.	234.	236.	238.	240.	242.	244.
28.	220.	222.	224.	226.	228.	230.	232.	234.	236.	238.	240.	242.	244.	246.
4.	222.	224.	226.	228.	230.	232.	234.	236.	238.	240.	242.	244.	246.	248.
11.	224.	226.	228.	230.	232.	234.	236.	238.	240.	242.	244.	246.	248.	250.
18.	226.	228.	230.	232.	234.	236.	238.	240.	242.	244.	246.	248.	250.	252.
25.	228.	230.	232.	234.	236.	238.	240.	242.	244.	246.	248.	250.	252.	254.
31.	230.	232.	234.	236.	238.	240.	242.	244.	246.	248.	250.	252.	254.	256.
7.	232.	234.	236.	238.	240.	242.	244.	246.	248.	250.	252.	254.	256.	258.
14.	234.	236.	238.	240.	242.	244.	246.	248.	250.	252.	254.	256.	258.	260.
21.	236.	238.	240.	242.	244.	246.	248.	250.	252.	254.	256.	258.	260.	262.
28.	238.	240.	242.	244.	246.	248.	250.	252.	254.	256.	258.	260.	262.	264.
4.	240.	242.	244.	246.	248.	250.	252.	254.	256.	258.	260.	262.	264.	266.
11.	242.	244.	246.	248.	250.	252.	254.	256.	258.	260.	262.	264.	266.	268.
18.	244.	246.	248.	250.	252.	254.	256.	258.	260.	262.	264.	266.	268.	270.
25.	246.	248.	250.	252.	254.	256.	258.	260.	262.	264.	266.	268.	270.	272.
31.	248.	250.	252.	254.	256.	258.	260.	262.	264.	266.	268.	270.	272.	274.
7.	250.	252.	254.	256.	258.	260.	262.	264.	266.	268.	270.	272.	274.	276.
14.	252.	254.	256.	258.	260.	262.	264.	266.	268.	270.	272.	274.	276.	278.
21.	254.	256.	258.	260.	262.	264.	266.	268.	270.	272.	274.	276.	278.	280.
28.	256.	258.	260.	262.	264.	266.	268.	270.	272.	274.	276.	278.	280.	282.
4.	258.	260.	262.	264.	266.	268.	270.	272.	274.	276.	278.	280.	282.	284.
11.	260.	262.	264.	266.	268.	270.	272.	274.	276.	278.	280.	282.	284.	286.
18.	262.	264.	266.	268.	270.	272.	274.	276.	278.	280.	282.	284.	286.	288.
25.	264.	266.	268.	270.	272.	274.	276.	278.	280.	282.	284.	286.	288.	290.
31.	266.	268.	270.	272.	274.	276.	278.	280.	282.	284.	286.	288.	290.	292.
7.	268.	270.	272.	274.	276.	278.	280.	282.	284.	286.	288.	290.	292.	294.
14.	270.	272.	274.	276.	278.	280.	282.	284.	286.	288.	290.	292.	294.	296.
21.	272.	274.	276.	278.	280.	282.	284.	286.	288.	290.	292.	294.	296.	298.
28.	274.	276.	278.	280.	282.	284.	286.	288.	290.	292.	294.	296.	298.	300.
4.	276.	278.	280.	282.	284.	286.	288.	290.	292.	294.	296.	298.	300.	302.
11.	278.	280.	282.	284.	286.	288.	290.	292.	294.	296.	298.	300.	302.	304.
18.	280.	282.	284.	286.	288.	290.	292.	294.	296.	298.	300.	302.	304.	306.
25.	282.	284.	286.	288.	290.	292.	294.	296.	298.	300.	302.	304.	306.	308.
31.	284.	286.	288.	290.	292.	294.	296.	298.	300.	302.	304.	306.	308.	310.
7.	286.	288.	290.	292.	294.	296.	298.	300.	302.	304.	306.	308.	310.	312.
14.	288.	290.	292.	294.	296.	298.	300.	302.	304.	306.	308.	310.	312.	314.
21.	290.	292.	294.	296.	298.	300.	302.	304.	306.	308.	310.	312.	314.	316.
28.	292.	294.	296.	298.	300.	302.	304.	306.	308.	310.	312.	314.	316.	318.
4.	294.	296.	298.	300.	302.	304.	306.	308.	310.	312.	314.	316.	318.	320.
11.	296.	298.	300.	302.	304.	306.	308.	310.	312.	314.	316.	318.	320.	322.
18.	298.	300.	302.	304.	306.	308.	310.	312.	314.	316.	318.	320.	322.	324.
25.	300.	302.	304.	306.	308.	310.	312.	314.	316.	318.	320.	322.	324.	326.
31.	302.	304.	306.	308.	310.	312.	314.	316.	318.	320.	322.	324.	326.	328.
7.	304.	306.	308.	310.	312.	314.	316.	318.	320.	322.	324.	326.	328.	330.
14.	306.	308.	310.	312.	314.	316.	318.	320.	322					

# HYDROGRAPH ROUTING

## OUTFLOW FROM NORTH ARROWHEAD LAKE

ISTAR	ICOMP	IECON	ITAFE	JFLT	JFRT	INAME	ISTAGE	INUTO
OUTFLOW	1	0	0	0	0	1	0	0
QLOSS	CLOSS	AUG	ROUTING DATA	TRFT	TRMF		LSTR	
0.0	0.000	0.00	1	1	0		0	
NSRTE	NSRTE	LAG	AMGRK	TRK	STORA	TRCOST		
1	0	0	0.000	0.000	1468.	-1		
START	1669.00	1670.00	1671.00	1672.00	1673.00	1674.00	1675.00	
END	0.00	591.00	1091.00	1680.00	2089.00	2490.00	2891.00	3292.00
SURFACE AREA	87.	129.						
CAPACITY	0.	433.	988.					
ELEVATION	1653.	1662.	1673.					

TOPEL	CONU	EXFD	PARWID	EXFL
1672.8	0.0	0.0	0.0	0.0

PEAK OUTFLOW IS 109. AT TIME 45.17 HOURS

PEAK OUTFLOW IS 220. AT TIME 45.17 HOURS

PEAK OUTFLOW IS 370. AT TIME 44.67 HOURS

PEAK OUTFLOW IS 509. AT TIME 44.67 HOURS

PEAK OUTFLOW IS 655. AT TIME 44.50 HOURS

PEAK OUTFLOW IS 809. AT TIME 44.33 HOURS

PEAK OUTFLOW IS 956. AT TIME 44.33 HOURS

PEAK OUTFLOW IS 1102. AT TIME 44.32 HOURS

PEAK OUTFLOW IS 1415. AT TIME 44.17 HOURS

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				.10	.20	.30	.40	.50	.60	.70	.80	1.00
RATIOS APPLIED TO FLOWS												
HYDROGRAPH AT INFLOW	(	1.00	1	192.	384.	576.	768.	960.	1151.	1343.	1535.	1719.
	(	2.59)	(	5.43)	10.87)	16.30)	21.74)	27.17)	32.60)	38.04)	43.47)	54.34)
ROUTED TO	(	1.00	1	109.	220.	370.	509.	655.	809.	956.	1102.	1415.
	(	2.59)	(	3.09)	6.22)	10.47)	14.41)	18.55)	22.90)	27.08)	31.22)	40.06)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION	INITIAL VALUE	SPILLWAY CREST	ICP OF DAM	DURATION	TIME OF	TIME OF
	STORAGE	1668.00	1668.00	1672.80	OVER ICP	MAX OUTFLOW	FAILURE
	OUTFLOW	433.	433.	942.	HOURS	HOURS	HOURS
		0.	0.	2208.			
RATIO	MAXIMUM	MAXIMUM	MAXIMUM	MAXIMUM			
OF	RESERVOIR	DEPTH	OUTFLOW	OUTFLOW			
FMF	W.S.ELEV	OVER DAM	CFS	CFS			
.10	1668.52	0.00	109.	109.	0.00	45.17	0.00
.20	1669.03	0.00	220.	220.	0.00	45.17	0.00
.30	1669.42	0.00	370.	370.	0.00	44.67	0.00
.40	1669.78	0.00	509.	509.	0.00	44.67	0.00
.50	1670.12	0.00	655.	655.	0.00	44.50	0.00
.60	1670.43	0.00	809.	809.	0.00	44.33	0.00
.70	1670.73	0.00	956.	956.	0.00	44.33	0.00
.80	1671.02	0.00	1102.	1102.	0.00	44.33	0.00
1.00	1671.53	0.00	1415.	1415.	0.00	44.17	0.00

Sh 9



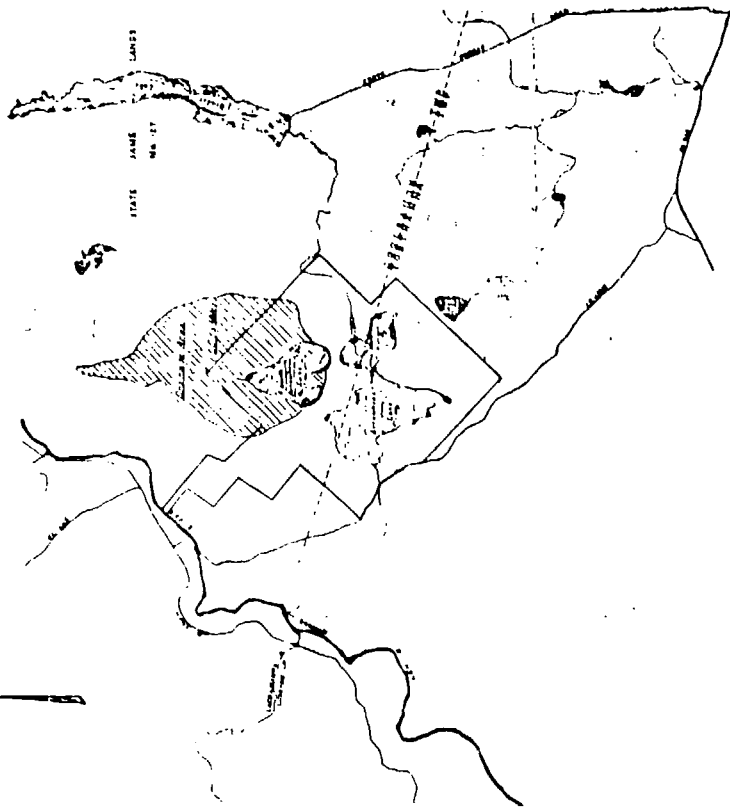
APPENDIX E  
REGIONAL VICINITY MAP  
&  
DRAWINGS

NORTH ARROWHEAD LAKE DAM  
APPENDIX E  
REGIONAL VICINITY MAP & DRAWINGS

TABLE OF CONTENTS

	<u>Sheet</u>
Regional Vicinity Map	1
Design Drawings:	
Location Plan	2
General Plan	3
Embankment Sections - Longitudinal	4
Embankment Cross - Sections	5
Spillway Plan & Details	6
Embankment Drop Gate, Sections & Details	7





# NORTH ARROWHEAD LAKE

Coolbaugh Township Monroe County, Penna.

## LIST OF DRAWINGS

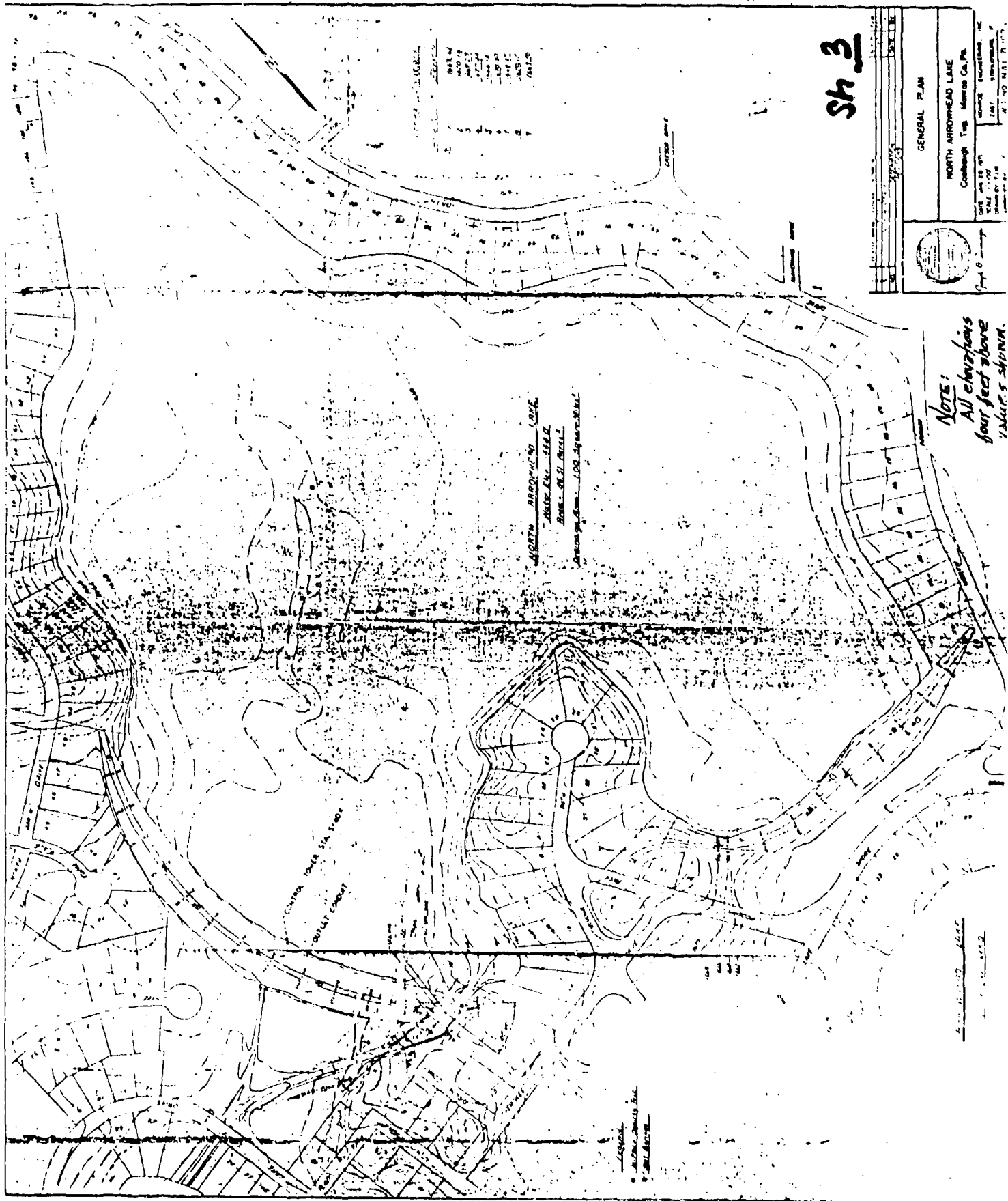
SHEET NO.	TITLE	DWG. NO.
1	Location Plan	NAL 7101E
2	General Plan	NAL 7102E
3	Embankment Section - Longitudinal	NAL 7103E
4	Embankment Cross - Section	NAL 7104E
5	Spillway Plan & Details	NAL 7105O
6	Embankment Drop Gate, Sections & Details	NAL 7106O

— LOCATION PLAN —  
 TRACED FROM RECORD USGS SHEETS



MONROE ENGINEERING, INC.  
 LISTED STRUCTURES BY  
 DWG. NO. NAL 71-

Sh 2



Sh 3

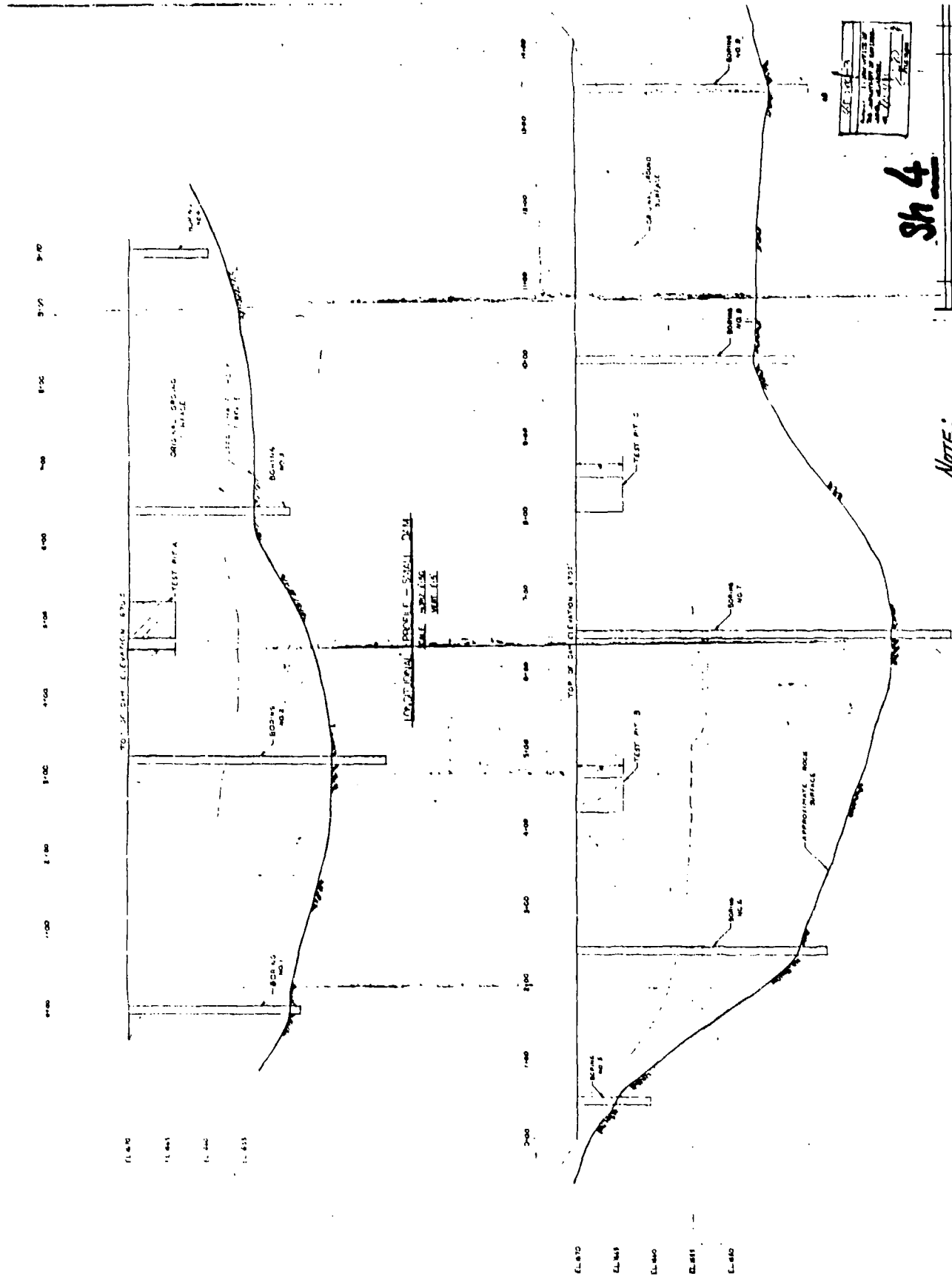
GENERAL PLAN

NORTH ARROWHEAD LANE  
Cathlamet, King Co., Wash.

Scale: 1" = 100' (Horizontal)  
1" = 20' (Vertical)  
Date: 11-11-12  
By: [Signature]

**Note:**  
All elevations  
four feet above  
values shown.

11-11-12  
11-11-12



**NOTE:**  
All elevations  
four feet above  
values shown.

LONGITUDINAL PROFILE - LARGE DAM  
SCALE 1" = 10' HORIZ.  
1" = 10' VERT.

**Sh 4**

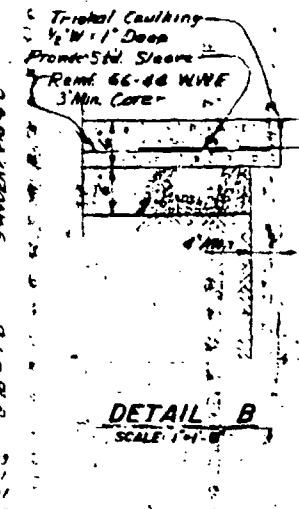
Embankment Section	
Longitudinal	
NORTH ARROWHEAD LAKE	
Cathlamet Twp., Clallam Co., Wa.	
DATE: March 19, 1954	SCALE: AS SHOWN
DESIGNED BY: J. C. BROWN	CHECKED BY: J. C. BROWN
DWG. NO. NAL 7403E	





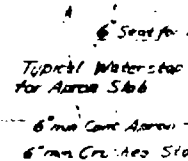
SCALE: 1" = 1'-0"

100



SCALE: 1/4" = 1'-0"

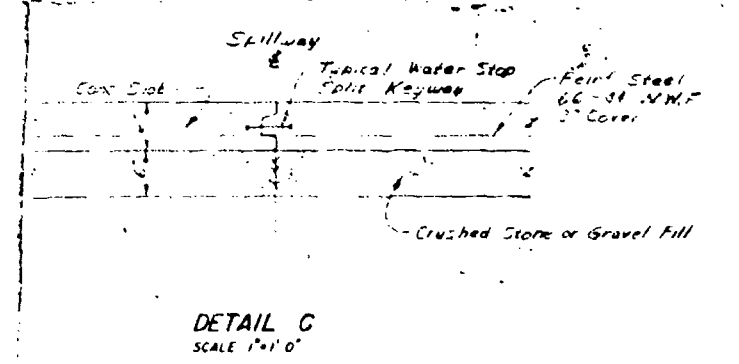
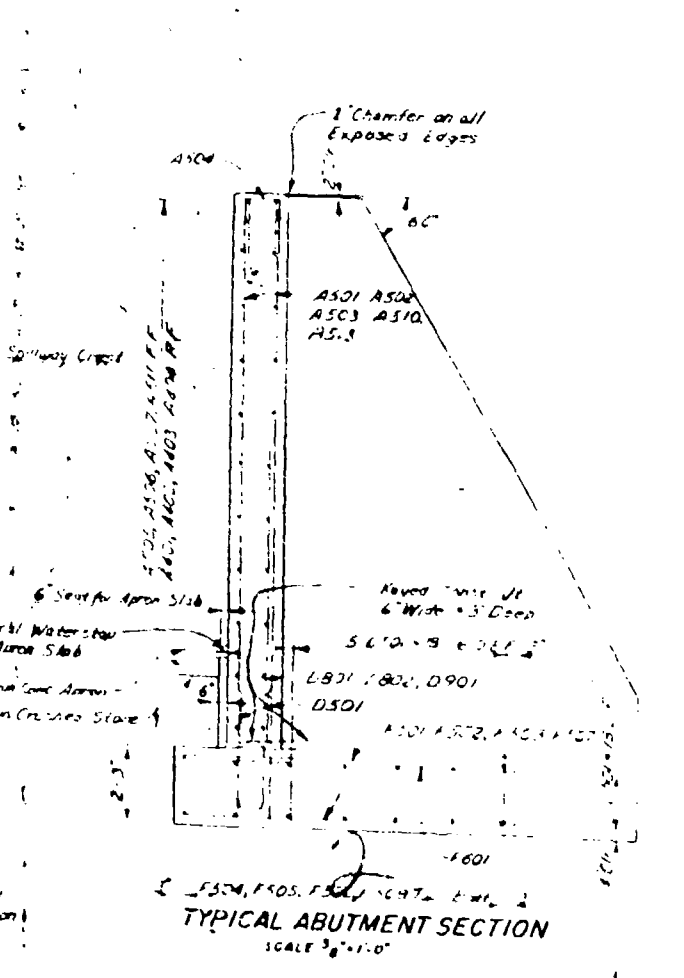
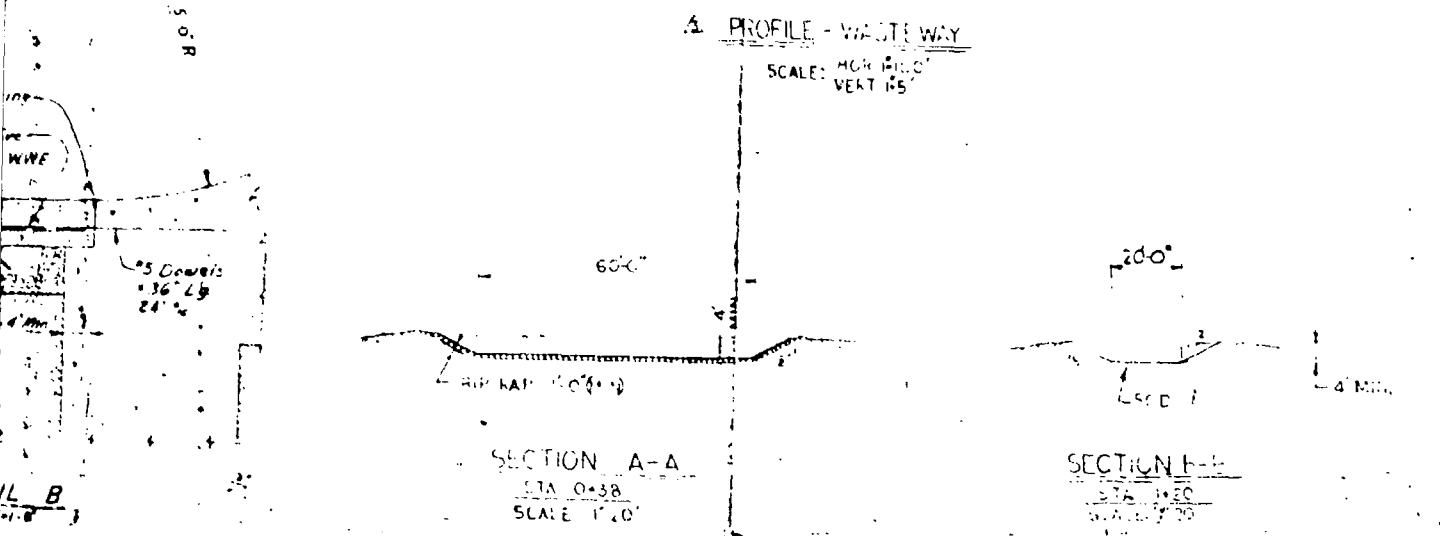
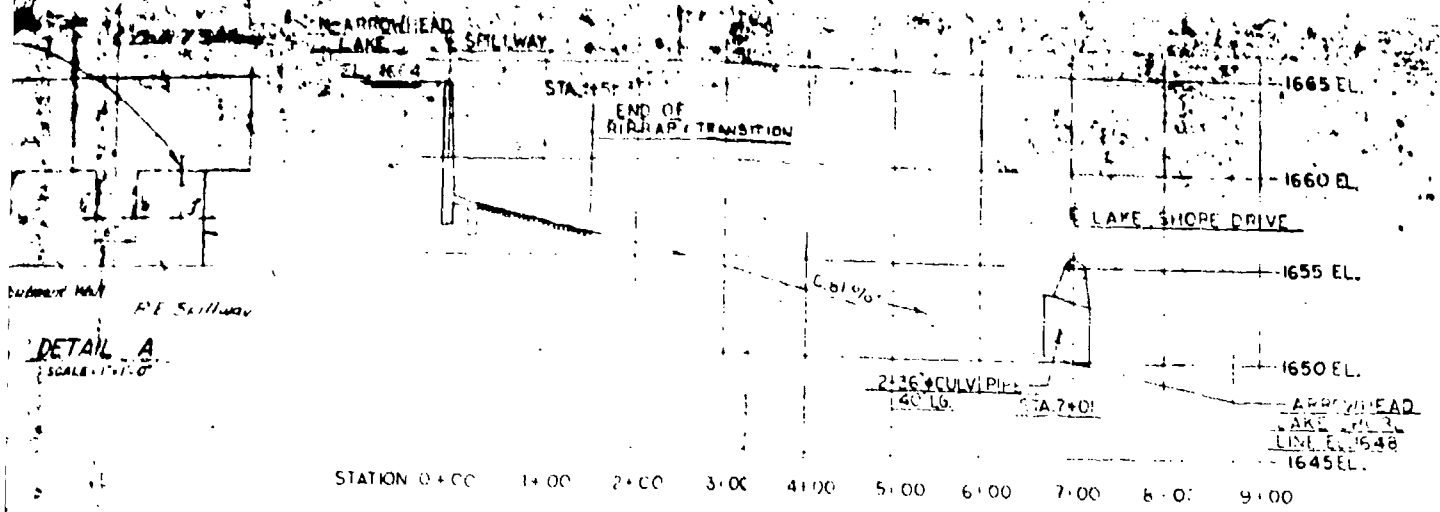
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SCALE 1" = 1.0'

Note:  
To be determined  
by field inspection  
by the Engineer

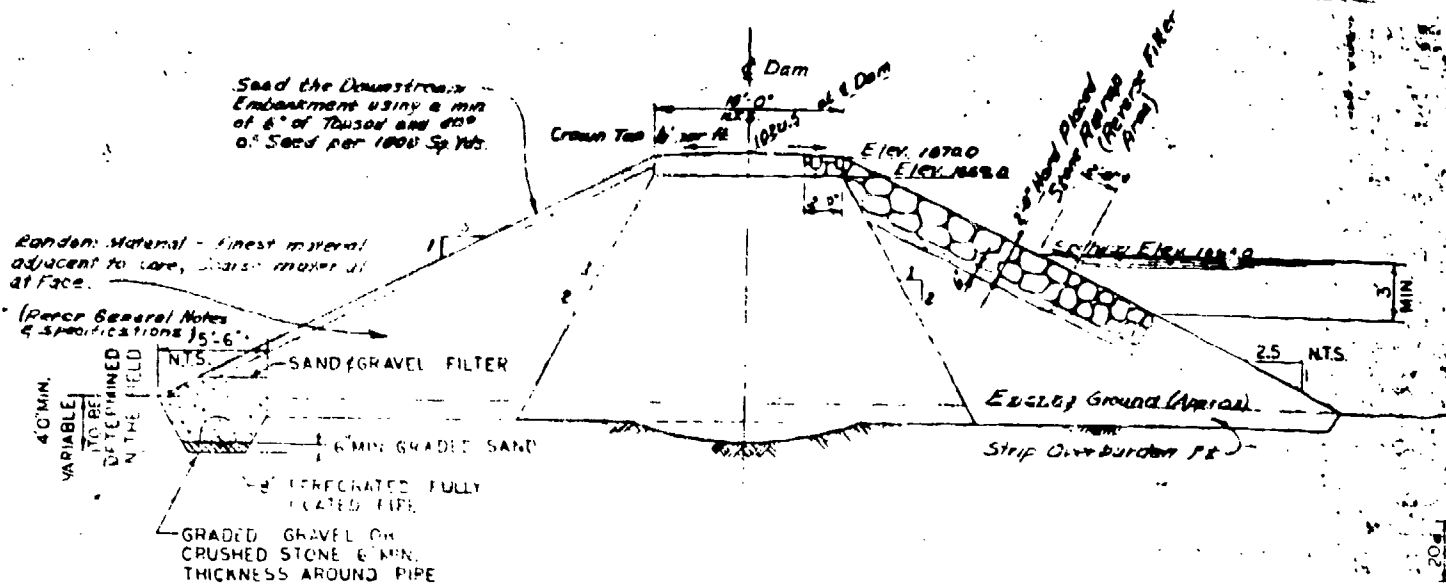




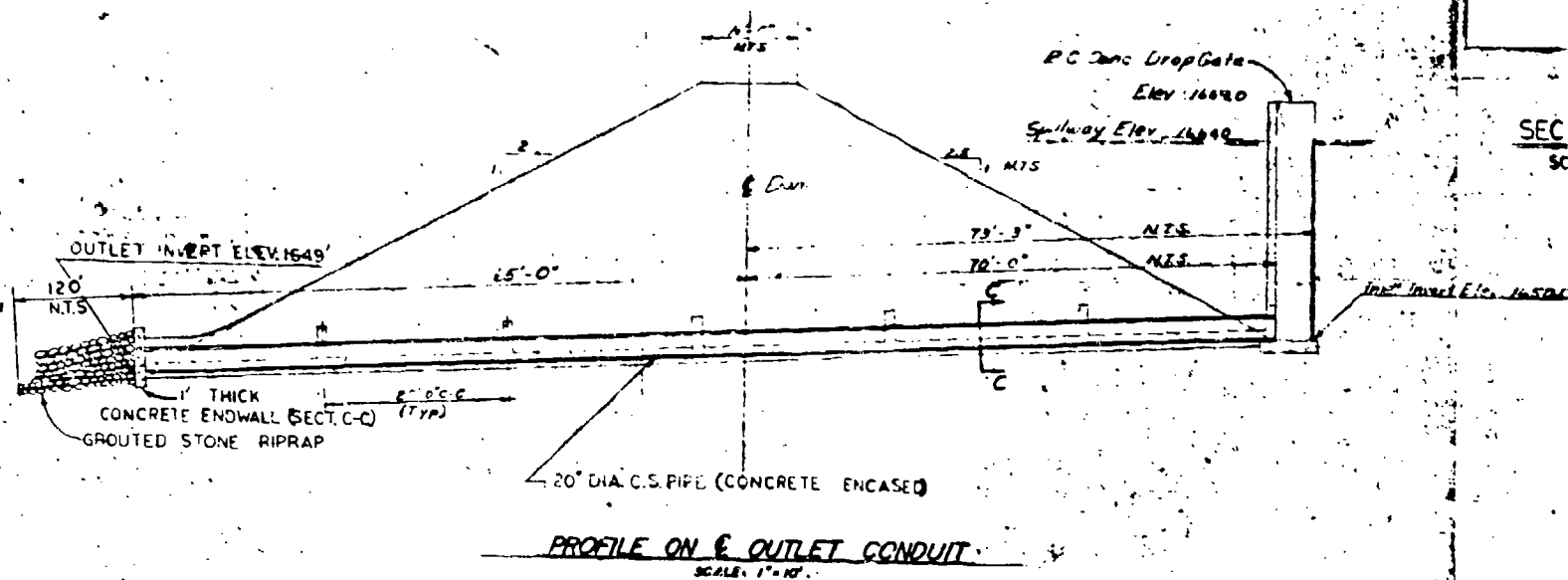
**NOTE:**  
All elevations four  
feet above values  
shown.

**SH 6**

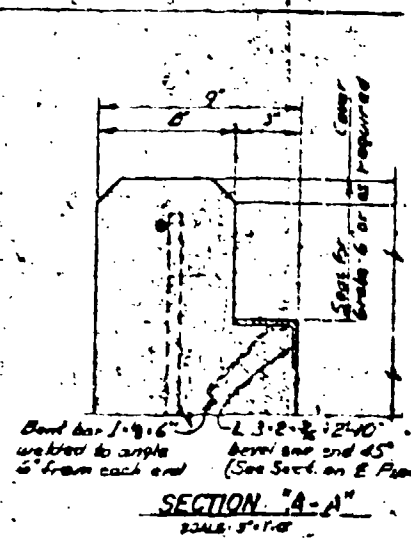
SECTION B-3 GENERAL PROVISIONS		DATE: BY:
NORTH ARROWHEAD LAKE COOLBAUGH TOWNSHIP, MONROE COUNTY, PA.		
PROPOSED DAM SPILLWAY PLAN & DETAILS		
SCALE: AS NOTED		



TYPICAL EMBANKMENT SECTION  
SCALE: 1"=5'



PROFILE ON E OUTLET CONDUIT  
SCALE: 1" = 10'



# GENERAL NOTES & SPECIFICATIONS

## EMBANKMENT

- Cutoff wall beneath dam shall be of concrete as indicated on the drawings, shall be formed in the existing material by injection of grout under pressure, or by any means acceptable to the Engineer.
- Impervious core cutoff trench may be carried to any depth at the contractor's option provided that the cutoff wall is extended to impervious substrate and embedded a minimum of 18 inches in impervious material at top and bottom.
- Subsurface data is given solely for general information and the Engineer assumes no responsibility for its accuracy. Depths of strata vary along the length of the dam but the approximate maximum depths are as indicated on the "Typical Embankment Section."
- Compaction shall be made to maximum density at optimum moisture in layers not exceeding six inches.
- Riprap upstream surface with fine gravel and sand to protect against wave action and provide a reverse filter in case of sudden drawdown.
- All materials and workmanship shall be in accordance with the best current practices of the construction industry.

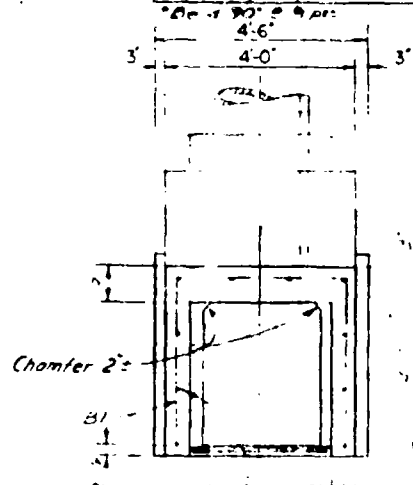
NOTE:

All elevations four feet above values shown.

## SECTION "C-C"

SCALE: 1/2" = 1'-0"

NO.	DATE	BY	CHKD.	APP.
1	5	17		
2	5	17		
3	5	17		
4	5	17		



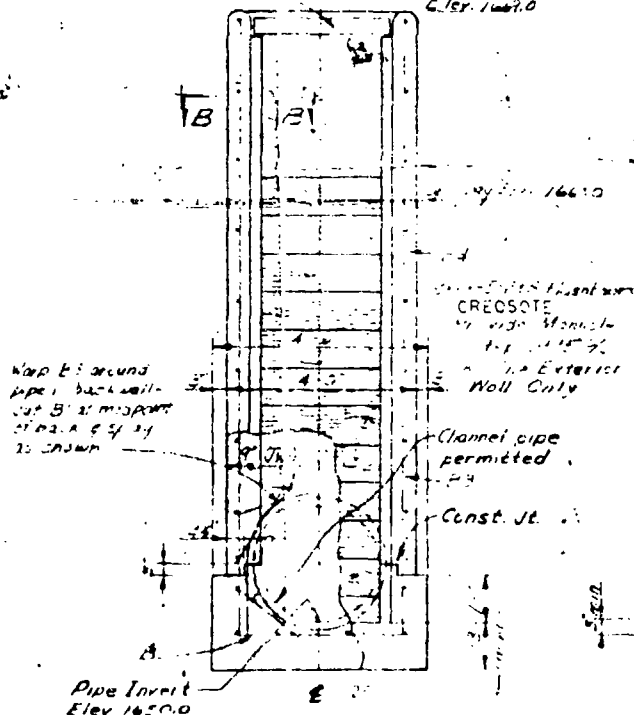
PLAN  
SCALE: 1/2" = 1'-0"

# GENERAL NOTES & SPECIFICATIONS

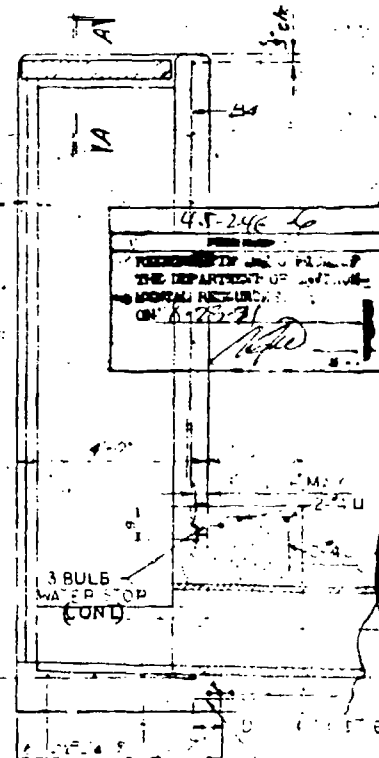
## DROP GATE

- All materials and workmanship shall be in accordance with the best current practices of the construction industry.
- All concrete shall be class A, 3000 PSI minimum compressive strength at 28 days and shall not be leaner than a mixture by volume of one part cement, two parts fine aggregate, and four parts coarse aggregate.
- Reinforcement bars designed for  $F_y$  equals 18,000 PSI. Provide 24 inches minimum cover on all bars unless otherwise noted except 14 inches around pipe in backwall.
- Chamfer exposed concrete edges 1" x 1" unless otherwise noted.
- The footing may be ordered by the Engineer to be at any elevation or of any dimensions necessary to provide a proper foundation.
- Angles forming flashboards and screen slots shall be welded together at no less than 18 inch centers by 3/16 inch fillet welds no less than 1/2 inch long.
- Bent bars welded to angles for anchors shall be kept a minimum of 6 inches from the ends of the angles.
- Lumber for flashboards shall be of a grade better than 1700F grade as designated by the National Hardwood Lumber Association.
- Cover gate to be of any design acceptable to the Engineer but shall be such that it can not be removed by unauthorized persons.
- Screens to be of a design acceptable to the Engineer, to retain fish and large debris but light enough to be easily removed.
- Drop gate is symmetrical about center line of pipe.
- Maximum design foundation pressure is less than one ton per square foot.
- Provide manhole steps inside, down one sidewall on 15 inch centers and of a design acceptable to the Engineer.

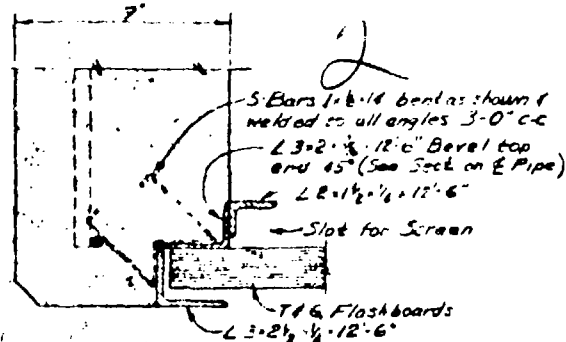
Gate— Elev. 1669.0



ELEVATION  
SCALE: 1/2" = 1'-0"



SECTION ON PIPE  
SCALE: 1/2" = 1'-0"



SECTION "A-A"

Sh 7

REVISION	DESCRIPTION	DATE
1	GENERAL REVISIONS	6/16/71 E.P.A.
NORTH ARROWHEAD LAKE		
COALBUSH TOWNSHIP, MONROE COUNTY, PA.		
PROPOSED DAM		
EMBANKMENT SECTIONS		
DROP GATE DETAILS		

MONROE ENGINEERING, INC.  
EAST STROUDSBURG, PENNSYLVANIA

APPENDIX F  
GEOLOGY

## SITE GEOLOGY

### NORTH ARROWHEAD LAKE DAM

North Arrowhead Lake Dam is located in Monroe County (PA) within the Pocono Plateau section of the Appalachian Plateaus physiographic province. The site is underlain by gently northwestward dipping beds of the Devonian Catskill group continental type sedimentary rocks. These consist of red to brown and gray shales, siltstones, sandstones and conglomerates varying from a few inches (flagstones) to several feet or more in thickness. Wisconsin epoch glacial deposits of sand and gravel mantle the rock surface and attain considerable thicknesses along valley floors and side slopes. Some swamp deposits occur where depressions or kettles exist as a result of the isolation and decay of ice during the retreat of the last glacial advance into the area.

No active structural faults are known to exist in the area.

Well developed jointing and fracturing occur in the bedrock units, particularly in the shales and siltstones. The Catskill rocks yield excellent quality groundwater and the formation is considered a fair to good aquifer. Glacial deposits occurring in the valley floor are quite permeable and act as excellent sources of groundwater and recharge to the underlying Catskill group sedimentary units.

